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Mosquito News

Published Quarterly
by the
AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

VOLUME 16 JUNE, 1956 NUMBER 2

U.S.A. 146

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13th Annual Meeting of the American Mosquito Control Association, Miami Beach, Florida, April 28–May 2, 1957

MOSQUITO NEWS

Official Publication of the American Mosquito Control Association, Inc.

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Published by

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

Printed by

Boyd Printing Company, Inc., Albany, N. Y.

A quarterly journal published on the 20th of March, June, September and December. Devoted to the improvement and the sound extension of mosquito control and related work as a vital public health service.

SUBSCRIPTION RATES

$5.00 per Year (U. S. money), Single Copies, $1.75
Mailed without charge to members of the Association.

MEMBERSHIP DUES—$5.00

BUSINESS COMMUNICATIONS

Communications relating to editorial matters and manuscripts submitted for publication in Mosquito News should be addressed to Donald L. Collins, Editor, Mosquito News, New York State Museum, Albany, New York.

F. P. Creadon, Advertising Manager, Desplaines Valley Mosquito Abatement Dist., 8130 Ogden Ave., Lyons, Ill.

Communications relating to subscriptions to Mosquito News, Membership in the American Mosquito Control Association, and other association matters should be addressed to T. G. Raley, Executive Secretary, American Mosquito Control Association, P. O. Box 278, Selma, Calif. Changes of address should reach the Secretary before the first of the month of publication.

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PAPERS AND PROCEEDINGS OF THE 12th ANNUAL MEETING

OF THE AMERICAN MOSQUITO CONTROL ASSOCIATION HELD JOINTLY WITH THE JEFFERSON COUNTY MOSQUITO CONTROL ASSOCIATION

BEAUMONT, TEXAS, FEBRUARY 5–7, 1956

THE PEST MOSQUITO PROBLEM AND ITS RELATION TO PUBLIC HEALTH

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Mosquitoes have always been recognized as pests just as sandspurs, crab grass, English sparrows and starlings. If a starling, for instance, should be found to harbor a virus, or other etiologic agent, of a human disease, the bird is no longer merely in the nuisance class but becomes a health hazard. When some of our so-called pest mosquitoes prove to be capable laboratory vectors of important human diseases, as they have, they, too, become distinct potential hazards to human health.

When our agricultural or other practices multiply mosquito breeding areas so that a hundred mosquitoes grow where one grew before; when these multiplied numbers of insects inflict bites that result in serious allergic, traumatic and infectious manifestations; when the hordes of venomous insects interfere with, or prevent, normal work and recreation, resulting in underdeveloped lands, lowered economic standards and an undernourished populace, then we can safely say that the so-called pest mosquitoes have a health hazard significance overshadowing their nuisance value. This has been recognized by the various State health departments and most of the nearly $50,000,000 spent annually for mosquito control is for the protection of man. There is now general acceptance of the World Health Organization concept that good health means not merely freedom from infirmity, but complete physical, mental, and social well-being.

Although there is increasing recognition of the public health importance of mosquitoes as pests, few data are available on this specific subject. A recent survey of the public health importance of irrigation mosquitoes in the Milk River Valley of northern Montana (8) illustrates the serious impact that these pest mosquitoes may impose upon a community. A house-to-house survey of 133 families showed that mosquitoes severely annoyed three-fourths of them and interfered with gardening and other healthful outdoor activities; about half reported that mosquitoes prevented their children from playing out-of-doors during the summer months. Outdoor community activities were essentially nonexistent. Most individuals in all of the families reported varying degrees of irritation from mosquito bites including itching, swelling, and secondary infections. An examination of representative individuals by the interviewing physician revealed that over 50 percent suffered abrasions following mosquito bite, and 40 percent of individuals living in lower class housing showed signs of secondary infection. Over 50 percent of the families used home medication; children were frequently taken to physicians for treatment of mosquito bites,

some even requiring hospitalization due to secondary infections or allergic reactions.

The official attitude of the Public Health Service toward pest mosquitoes was expressed by the Acting Surgeon General in 1950 in a letter to the State and Territorial Health Officers. He stated that pest mosquitoes should receive more attention from health authorities than had been previously accorded them (1, 7, 11). Most State health departments are in agreement with this, and there are increasing requests for the Public Health Service to assist in the solution of pest mosquito problems. These problems fall naturally into two main categories: (1) salt marsh mosquito problems, and (2) fresh water mosquito problems.

SALT MARSH MOSQUITO PROBLEMS

Throughout their known history, the Atlantic, Gulf, and Pacific coastal areas of the United States have been plagued with hordes of salt marsh mosquitoes. These mosquitoes also occur in a number of inland areas usually associated with oil or mining operations and in the vicinity of the Great Salt Lake. Wherever salt marsh mosquito breeding occurs, it is generally characterized by the production of prodigious numbers of the pests, resulting in extreme annoyance to man and animals in the surrounding areas. The intensity of this problem has been responsible for retarding the development and utilization of vast segments of our coastal areas. The magnitude of the annoyance problem is aggravated further by the dispersal habits of certain species.

There are five principal species of salt marsh mosquitoes in the United States. *Aedes sollicitans* occurs along the Atlantic and Gulf Coasts and at some inland points, particularly in the eastern half of the country. *Ae. taeniorhynchus* is found along the Atlantic, Gulf, and southern California coasts, and at some inland points in the southern part of the country. *Ae. cantator* is limited to the Atlantic Coast from Virginia northward. *Ae. squamiger* is found along the Pacific Coast from San Francisco southward. *Ae. dorsalis* occurs throughout the northern half of the United States from the Atlantic to the Pacific, breeding in both fresh and salt water (5).

Salt marsh mosquitoes have been shown in laboratory tests to be capable of transmitting such diseases as encephalitis, yellow fever, and filariasis. The potentiality of salt marsh mosquitoes serving as natural vectors of diseases must be recognized. However, the principal known public health problems associated with salt marsh mosquitoes are: (1) the extreme annoyance to man and interference with his activities in affected areas, and (2) the severe reactions, including secondary infections, experienced by many individuals bitten by these pests. Salt marsh mosquitoes also are important vectors of heart worms in dogs in southeastern United States.

During recent years, the agricultural, industrial, and recreational development of the coastal areas has proceeded rapidly, with a consequent increase in the human populations exposed to mosquito annoyance. In some instances, the development of coastal areas has aggravated existing salt marsh mosquito problems in an unexpected manner. Greatly increased use of fresh water for agricultural and industrial purposes has resulted in diminished stream flow and subsurface supply, thereby allowing the intrusion of salt water. In a number of localities, the liberation of salt water and other wastes from oil drilling and certain mining activities has resulted in conditions favorable to prolific production of salt marsh mosquitoes (3, 4). On occasions, the magnitude of the nuisance which resulted has forced the industries that created the problem to suspend operations temporarily.

To evalaute the importance of the present salt marsh mosquito problem in the United States, in July 1955 the Communicable Disease Center of the Public Health Service mailed an inquiry to the health officers of 24 states where these insects normally occur. This inquiry requested information regarding the present status of the problem and certain data on control activities. Twenty-two states reported salt

marsh mosquito problems ranging from moderate to severe; the other 2 states considered the problem to be of less magnitude. In some states, the trouble is highly localized; in others, it is extensive. In 6 states, 71 organized mosquito abatement districts are conducting control operations against salt marsh mosquitoes. A much larger number of individual salt marsh mosquito control programs are being conducted in cities and communities, and on military bases in 15 states. (These states include 10 that do not have organized mosquito abatement districts.) The majority of states responding to the inquiry indicated that the health department is either the designated state agency having responsibility for salt marsh mosquito control or is providing technical consultation and guidance to local mosquito control activities.

There is a growing recognition on the part of state and local governments that these pests are a menace to the health and welfare of the populace. Several states have well developed and extensive salt marsh mosquito control programs, and others are taking positive measures to initiate control activities. In some states, the mosquito abatement districts receive financial support, technical consultation, and guidance from the State health department, these activities being considered normal health department functions and responsibilities. In some other states, this help is supplied by the State agricultural, highway, or other departments. In a few instances, well organized and effective local mosquito abatement programs are being carried out with very little State support or participation.

Although the Public Health Service has the authority and is conducting some work on salt marsh mosquitoes, no funds are available specifically for salt marsh mosquito research or control activities, and only limited assistance can be provided to State programs. However, consistent with the man power available, the Communicable Disease Center does, upon request, conduct joint surveys with representatives of State health departments and makes recommendations to help solve the problem (3, 4).

Present salt marsh mosquito control measures in many instances are applicable only under the specific ecologic conditions of the locality involved. In addition, certain measures require large expenditures of money and are only partially effective. There is certainly need for more knowledge on permanent control measures (drainage, filling, impoundment, salt water extrusion) as to their costs, effectiveness in reducing mosquito production, adaptability to different problem areas, and their influence on other related elements such as wildlife conservation and land values. Basic to all control studies is extensive research on the biology of the various species concerned. These investigations must coincide with the habitat types involved and necessitate in many instances long-term studies. In essence, the solution to salt marsh mosquito problems can be met only through a combined program of laboratory and field research on control methodology and salt marsh mosquito biology. We hope that this need can be met.

FRESH WATER MOSQUITO PROBLEMS

Among the most extensive and severe of the fresh water pest mosquito problems are those associated with the development and utilization of water resources. The proper development and utilization of these resources is a major factor in the future economic progress of the nation, and it is essential that their benefits not be impeded by the creation of public health problems.

State health departments are cognizant of the public health importance of the "man-made" mosquito problems and are making commendable efforts to meet the situation. The Public Health Service is responsible for the incorporation of adequate mosquito prevention and control measures into development programs for the nation's major river basins. In this capacity, it works very closely with the

various State health departments and the various Federal agencies concerned with river basins developments.

The types of water resource development projects with which the more important fresh water mosquito problems are associated are irrigation systems and multipurpose impoundments.

A tremendous expansion of irrigation is currently under way in the United States, particularly in the West. Over 25 million acres are now under irrigation, representing a capital investment of some two billion dollars, and each year about a million acres more are added. This rapid expansion is being accompanied by proportionate increases in the production of mosquitoes, creating public health problems in most irrigated areas. Among the more important of the mosquito species involved are *Ae. vexans, Ae. dorsalis, Ae. nigromaculis, Psorophora confinnis, P. discolor,* and *Culex tarsalis.* The latter species is the principal recognized vector of western equine and St. Louis encephalitis in the western states. Also, it bites man quite readily and is an important pest species aside from its role in disease transmission.

Among the major areas affected by mosquitoes are: (1) the North and South Platte River Valleys of Nebraska, Colorado, and Wyoming; (2) the Milk River Valley in northern Montana; (3) the deep-well irrigated areas of the Southern High Plains of Texas; (4) the Lower Rio Grande Valley; (5) the irrigated basins of the Colorado River and its tributaries; (6) the Great Basin in Utah; (7) the Snake River Valley in Idaho; (8) the Central Valley of California; (9) the Columbia Basin in Washington; and (10) the rice-growing areas of the Mississippi Delta. As an example of the magnitude of these problem areas, the Columbia Basin project alone will eventually bring a million acres under irrigation.

Mosquito production in irrigated areas is primarily associated with faulty irrigation systems, improper land preparation, or inadequate drainage. Solution of these problems is, therefore, of mutual interest to public health and agriculture.

Many types of mosquito problems are associated with impounded water projects. Reservoirs developed for flood control, water storage, hydroelectric power generation, and navigation may produce large populations of mosquitoes if improperly constructed or managed. In impoundments in the southeast, the principal malaria mosquito, *Anopheles quadrimaculatus,* and, to a lesser extent, other anophelines, usually constitute the most abundant species. During the spring flood surcharges or when reservoirs are refilled during periods of heavy summer rains, prolific production of *Ae. vexans* and other pest culicines also may result. For impoundment projects, it is important that mosquito control be "built into" the design and operational plans.

In water fowl refuges or where these are included in impoundments, heavy mosquito production frequently occurs. It has been demonstrated that game management practices can be developed which are mutually beneficial to mosquito control and wildlife. More attention should be given to such potentialities.

Certain species of mosquitoes are domestic in habit. These usually occur as the most persistent problem species in and around the home in urban areas. The yellow fever mosquito, *Ae. aegypti,* is our most domestic species. It is always found closely associated with the home and often becomes a localized pest of some importance. However, the mosquito most commonly found inside dwellings belongs to the *C. quinquefasciatus-pipiens* complex. While this species breeds in artificial containers around dwellings, it also shows a predilection for breeding sites having high organic pollution, such as sewage lagoons, septic tank effluent, or wastes from vegetable or animal processing plants. The use of chemical control measures in these situations is complicated by the fact that most insecticides are inactivated considerably by the high organic content of the breeding medium.

Woodland mosquitoes of the genera *Aedes* and *Psorophora* breed in rain- or

snow-fed pools in or near forests and severely attack native animals and the hapless woodsmen and sportsmen. The ferocity of such attacks occasionally is so great as to drive humans from the woods and to interfere seriously with vocational and recreational activities. Because of the widespread occurrence and inaccessibility of breeding areas, practical control methods for these mosquitoes are unknown except for restricted adulticidal operations (2, 9, 12).

Mansonia mosquitoes are avid biters which readily attack man. Populations of these mosquitoes in localities having large permanent marsh or lake areas thickly covered with vegetation, such as water lettuce, water hyacinth, pickerel weed, and cattail, may become so great as to constitute a real menance to nearby communities (2, 9, 10). Both *Mansonia indubitans* and *M. perturbans* have caused extreme annoyance in central Florida, and *M. perturbans* is considered an important pest in New Jersey also (6). Control measures against *Mansonia* mosquitoes are difficult and expensive, and satisfactory methods are not available.

GENERAL CONCLUSIONS AND PROGRAM POTENTIALITIES

It will be noted that the problems discussed are very diverse and that practical solutions have not been developed. The need for concerted study of these various problems is apparent. The standard of living in this country has ascended to the desirable level at which people are no longer satisfied merely to be free of the scourges of mosquito-borne diseases. Justifiably, they believe that they are entitled to pool their resources and efforts to achieve relief from the voracious attacks of blood-sucking mosquitoes just as they do to control pollution of the water they drink and the air they breathe.

This new awareness and desire to conquer this problem has been demonstrated by the progressive action of several leading public health organizations in the adoption of resolutions advocating and supporting pest mosquito control activities. Notable among these organizations is the State and Territorial Health Officers Association which adopted the following resolution during its November 1955 meeting: "That a comprehensive program be established in the Public Health Service on salt marsh mosquito control, including laboratory and field research, demonstrations, and technical consultation, to meet the increasing salt marsh mosquito problem in many areas of the United States, including territories and possessions." During November 1955 the American Public Health Association passed an even broader resolution, which includes the mosquito problems associated with water resources development and reads as follows: "Resolved, that the American Public Health Association recommends that a program of research, demonstration and technical consultation in control of mosquito breeding in salt marshes, irrigation systems and other water resources developments, be undertaken by the United States Public Health Service and by State health departments." The Florida Anti-Mosquito Association, in its December 1955 meeting, unanimously passed a resolution calling for support of national movements for a program of research, demonstration, and technical consultation in controlling all mosquitoes which adversely affect the health, comfort, and welfare of the people.

During January and February 1956, several identical bills were introduced in the U. S. Senate and House of Representatives calling for an authorization of a Federal expenditure for work on the mosquito problem.

SUMMARY.—The several problems of the pest mosquitoes of the United States are discussed. These mosquitoes are divided into three principal groups for consideration. They are (1) salt marsh mosquitoes, (2) those fresh water species associated with man's development of water resources, and (3) fresh water species occurring in natural habitats relatively uninfluenced by man's activities. The impact of large pop-

ulations of pest mosquitoes on the public health of a community is described. Also considered are the serious economic losses resulting from the presence of these pests.

Current interest by the public and by mosquito control organizations and health departments in inaugurating measures to alleviate this severe problem is increasing. Much research is necessary to develop the knowledge upon which final successful control operations must be based.

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HISTORY OF *AEDES AEGYPTI* CONTROL WORK IN TEXAS

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In 1922, Texas suffered a very severe outbreak of dengue fever, estimated to have affected a million people, including some 70 percent or more of the citizens of Galveston and Houston. In the following year yellow fever edged its way up into Central Mexico, and there was fear that it might eventually enter Texas, either by land or sea. The United States Public Health Service therefore set up *Aedes aegypti* control programs in border towns from El Paso to Brownsville, in the Texas ports, and in the city of San Antonio, since this city, which has been called the Mexican capital of the United States, is the first destination of many immigrants from Mexico. I was placed in charge of the program from Laredo to Galveston. The breeding index of *Aedes aegypti* (i.e., percentage of premises with one or more breeding containers) was successfully brought down in most places, including San Antonio, to what we thought was a safe level of less than five percent. This was done by means of house to house inspection under the direction of a local supervisor who worked in conjunction with the local health department, and by an

extensive publicity campaign. That the results were fairly good may be judged from the fact that in early September eight cases of dengue, in widely scattered parts of San Antonio, were reported. Investigation showed that all eight worked in one block in the wholesale district of the city where there was a flooded basement, breeding *Aedes aegypti,* that had escaped the notice of inspectors, and whence no complaints had been made concerning the abundance of mosquitoes. The significant point is that not a single secondary case ever developed.

After that episode, *Aedes aegypti* control was largely neglected for nearly 20 years. With our entrance into World War II in 1942, it was felt that conditions were favorable for the possible introduction of dengue, and that if an epidemic got started it might create havoc in areas important to the war effort, either because of troop concentrations or presence of important industries. The Malaria Control in War Areas branch of the United States Public Health Service in Atlanta, the forerunner of the present Communicable Diseases Center, therefore undertook the control of *Aedes aegypti* as well as malaria-carrying mosquitoes in war areas, in conjunction with the several coastal states involved.

To make a long story short, after being approached first by the Texas State Health Department in Austin, then by M.C.W.A. in Atlanta, and finally by the Surgeon General's office in Washington, I found myself a Special Consultant in charge of *Aedes aegypti* control in the State of Texas.

Our first task was a preliminary survey to determine in what cities or areas control programs should be set up. We made spot checks of what were considered likely *Aedes aegypti* breeding areas all along the border and coast from El Paso to Orange, and also in San Antonio and a number of other inland cities, including Austin, Dallas, Fort Worth and Waco. This survey turned up some very unexpected and highly interesting facts. No *aegypti* breeding was found in El Paso, and a negligible amount in the other inland cities except San Antonio. *Aegypti* breeding was extensive in Laredo, throughout the Rio Grande Valley, and in Corpus Christi, Houston and Galveston along the coast. In all of these places breeding indexes of from 20 to 40 percent were recorded. We found *Aedes aegypti* breeding in a spittoon in one Health Officer's office in the Rio Grande Valley while he was telling us he doubted that this mosquito was abundant in his area. To convince the Health Officer at Galveston, who was "from Missouri" and wanted to be shown, we took him on a tour of a block across the street from the City Hall, where we found a 100 percent index, with an average of about 2½ breeding containers per premise. On this survey, or subsequently, we found literally many hundreds of breeding places in containers in cemeteries, thousands in barrels of water for fire protection in cotton compresses and warehouses, dozens in water buckets in downtown stores, and hundreds more in jardinieres or in containers growing plants in water in homes. In one fine home where we heard bitter complaints about nothing being done about mosquitoes breeding in an adjoining bayou (which was free of breeding), we counted 21 flower-growing containers breeding *aegypti,* plus a 3′ × 5′ sump in the basement which was teeming with larvae!

More striking, however, than the almost ubiquitous *aegypti* breeding in these cities was the complete or almost complete absence of it in certain other cities. Whereas some 35 percent of all the premises in Galveston were producing *aegypti,* at Texas City, 10 miles away across the bay, not a single *aegypti* breeding place was found, nor were any found at either Orange or Port Arthur. At Beaumont a half dozen of the most likely blocks in the less tidy parts of the city were negative, but a few barrels on a wharf, where the prevailing wind was fortunately away from the city, were found breeding. In contrast to Houston's city-wide index of 30 percent or more, no breeding places were found in Baytown, La Porte or ad-

joining cities on the first survey, although on a subsequent check, in late August, two breeding places in adjoining premises were found in Baytown. These and other examples of uneven distribution of *Aedes aegypti* in Texas cities were discussed in a paper some years ago (Chandler, 1945) and an explanation for it suggested. Work by Hatchett (1946) indicated that the climate of South and Central Texas, where there are alternating periods of warm and cold weather, is highly destructive to *Aedes aegypti* since in scattered small containers (secondary foci) the eggs hatch and the larvae or newly emerged adults are subsequently killed. In large or protected containers, however, such as cisterns, fire-protection barrels, indoor sumps, etc. (primary or "mother" foci), breeding can continue through the winter, and seeding of secondary foci occurs immediately upon the advent of warm weather. In the semi-tropical Rio Grande Valley "mother foci" would include a much larger range of containers than in the more northern cities. Even as far south as Beeville and Kingsville, however, the influence of cisterns was apparent. Beeville was full of them and had extensive *aegypti* breeding, whereas no cisterns or barrels were found in Kingsville and no *aegypti* breeding was discovered there. In Corpus Christi, Houston and Galveston the most important mother foci were fire-protection barrels (there were 7000 to 8000 in Galveston, and over 10,000 in Houston) and cisterns, some in the form of large overhead cypress tanks, some underground, and some in attics or basements. In San Antonio winter carry-over was not so often in cisterns as in shallow wells with brick or concrete walls and indoor water containers in areas without piped water supply, and in flooded basements, indoor water plants, etc., throughout the city.

After this preliminary survey it was decided to establish local *Aedes aegypti* control projects in Laredo, two in the Lower Rio Grande Valley (Hidalgo County and Cameron County), Corpus Christi, San Antonio, Houston and Galveston. The State Health Department kindly established a separate headquarters for the *Aedes aegypti* work in Houston, for my benefit. With help from the State and from M.C.W.A. we selected supervisors for each of the seven projects, and arranged for office space and more or less local assistance in each area, in which the local Health Departments were very helpful. The organization thus began with local projects which were responsible to the Houston office, this in turn to the Austin office, then M.C.W.A. in Atlanta, and finally the Surgeon-General's office in Washington. Through these channels filtered all appointments, leaves, promotions, reimbursements, requests for equipment, etc., and then, after being duly pondered over, they eventually filtered down again, leaving trails of forms scattered like roses along the way.

The work of the local projects was directed mainly towards three things—education, house to house inspection, and elimination of breeding places, particularly primary foci.

The educational program was an all-out one which left no possible approach untried. This included newspaper articles; radio plugs; leaflets in Spanish and English distributed by inspectors or in schools; lectures to schools, churches, boy scouts, civic clubs, garden clubs, P.T.A.'s, etc.; poster contests in schools; and back door chatter by inspectors. Dengue became as well known as polio is today, and even some of the doctors took to diagnosing cases. We investigated an alleged outbreak in Baytown which turned out to be an epidemic of food poisoning acquired at a banquet in Houston on the night before.

The inspection program depended primarily on a small force of paid inspectors —from one and a supervisor in Hidalgo County to several dozen in Houston. Some were paid by the Public Health Service, but most of the health departments assigned, or paid for, additional men. To recruit these men in 1942, when nearly every male citizen who was able to walk and carry a gun was in the Armed Forces,

was no small job. We tried to get men who were willing to work, had enough tact and culture to talk to housewives, could learn to recognize a mosquito larva, if not an *Aedes aegypti,* and were conscientious and punctual. We had to use high school boys, men past 70, partial cripples, occasional alcoholics, and even members of the gentler sex (some of whom did excellent work). All were given indoor instruction, then sent out with a tried inspector, and by the end of about a week, if still with us, he or she went out on his or her own responsibility to assigned blocks. We had to use a system of "snoopervision" to keep some of our men from emptying beer mugs instead of tin cans, but considering all things I think the degree of efficiency achieved was quite remarkable. In some projects additional inspectional help was obtained from boy scouts, school children, and even firemen. These inspections accomplished two things—they actually got some inspections done and corrections made, and they had great educational value, not only for the children who participated, but also for the parents who heard about their experiences. In Corpus Christi all the boy scouts in the city were given preliminary training and then on one big day every house in the city was given an inspection. On our program it was never possible to make as frequent reinspections of premises as was done in Key West, where an out and out eradication program was developed. In Key West there were a number of special details, and, I believe, regular reinspections were made every ten days. In Houston alone this would have required the services of 600 men. However, by concentrating on the areas of the cities where the highest indexes were found, and with the cooperation of other agencies and arousal of public interest, it was possible in all our projects to reduce the initial indexes of 20 percent to 40 percent to from 1.5 to 5 percent.

In the larger cities, particularly Houston, San Antonio and Galveston, special inspectors were assigned to business areas and establishments, and the supervisors themselves made the chief contacts with cotton warehouses, stores, etc., where barrels or buckets were in use.

Corrections were made or attempted wherever *aegypti* breeding was found, or where it could be expected. Enormous numbers of containers were turned bottoms up, or collected and disposed of (occasionally involving some difficulties for the garbage department). Old tires were slashed, burned, placed under cover, or treated with phenothiazine (DDT was not then available). Sumps and flooded basements were treated with chemicals, lily ponds were stocked with *Gambusia;* and flower vases in cemeteries and water plants in homes were treated with bits of phenothiazine—treated paper. But particular stress was laid on elimination of mother foci. Managers of stores and warehouses were made responsible for preventing mosquito breeding in their establishments, and nearly all cooperated excellently. Cisterns were eliminated wherever the owners could be persuaded to part with them, and eventually most of them disappeared. Practically all of the underground ones were sealed in, and hundreds of overhead ones were torn down. Those that were left were temporarily treated with kerosene, but eventually were mosquito-proofed with plastic screen; this screening was still in good shape when examined 8 to 10 years later.

With the end of the war, the M.C.W.A.-sponsored *Aedes aegypti* control came to an end, and those of us who had worked very hard on it during the war years waited with much interest, and I must admit with not too much optimism, to see what would happen to the indices that we had seen reduced, on an average, by about 90 percent during the war years from 1942 to 1945.

In 1945, the cities where we had operated recognized the advantages of house to house inspection over the old haphazard complaint method of detecting sanitary defects, and most of them not only saved the majority of our trained men, but added

to them, and integrated the *Aedes aegypti* inspection with the general sanitation program of the city, making inspections for sewage disposal, garbage, rat-harboring places, animal nuisances, fly breeding, etc. In Houston there is still a corps of about a dozen house to house inspectors, and a corps of four follow-up inspectors, both under the direction of men who were active in the *aegypti*-control program.

To our very great gratification, the results of our four years of work have been nothing short of spectacular. With no special effort to control them after 1945, *Aedes aegypti* almost or completely disappeared from Texas cities and areas where there had been active projects. In Corpus Christi, according to R. H. Waldrop, who was supervisor there in the latter part of the *aegypti* program, *Aedes aegypti* has been completely eradicated; the last ones found were in a junk yard in 1948. One of the most efficient and accurate inspectors under Waldrop is now Vector Control Supervisor for the Health Department in Corpus Christi. Like anyone who has once been trained to look for *aegypti* breeding places, he cannot pass a likely place without looking, but in spite of that, and in spite of a reward offered by Waldrop for any *aegypti* found in the city, none has been found, even by the P.H.S., State and local inspectors in a reconnaissance survey in 1952. Bradley and Atchley (1953) reported that *Aedes aegypti* had not been reported in Key West for two seasons and apparently had been eradicated from that island "Thus," they said, "North America has one successful eradication project to its credit." It seems evident that Corpus Christi, which had a general, city-wide, full season index of about 10 percent in 1942, which means indexes of from 20 percent to 40 percent in some areas of the city at the peak of the season, must also be included in the elite class of *aegypti*-free cities, and probably was the *first* one.

In Galveston, which probably had more *aegypti* breeding than any other city in the United States in 1942, *Aedes aegypti* is on the verge of extermination. Dr. Donald Micks, medical entomologist at the University of Texas Medical Branch, doing research on mosquitoes, tells me that he has not seen a wild *Aedes aegypti* in Galveston since he arrived there several years ago, and has to rear them to get specimens for class demonstration. I think it is safe to say that when an occasional *aegypti* is found in Galveston, e.g., one breeding place in 643 premises inspected in a reconnaissance survey in August of 1952 (see below), it is probably the result of a recent importation. Conditions apparently are no longer favorable for continued *aegypti* breeding in Galveston.

The same situation apparently exists in Laredo, where breeding places are very rarely found (a single one was found in 226 premises inspected in 1952), although there is abundant breeding across the Rio Grande in Nuevo Laredo, Mexico.

In Houston a similar condition prevails. Whereas in the war years I or my students could always find *Aedes aegypti* for class use in September near the Rice Institute, for the last five years we have searched in vain in what were formerly prolific breeding places. Inspectors in the city health department who, like those in Corpus Christi, are involuntarily attracted to looking for *aegypti* in likely places, have not seen any for years. In the 1952 reconnaissance survey a 9 percent index was found in an inspection of 565 premises in August, but the inspectors were guided to the most likely places by Mr. Waldrop, who knew them exceptionally well. Such an index in a few inspections in the most likely places at the peak of the season, if compared with a city-wide index for a full year, may give a very erroneous picture of the true situation. My belief is that even in Houston, *aegypti* is not far from extermination, and might be exterminated if an effort were made to find mother foci which escaped detection in 1942–1945, or have since become established.

In 1952 C.D.C. workers in cooperation with state and local health departments

made brief reconnaissance surveys of a number of cities in the *Aedes aegypti* belt of southern United States, including many that had had wartime *aegypti* control projects. Bradley and Atchley (1953), in reporting the results of this survey, reported negative findings in Corpus Christi, Hidalgo County (McAllen and Mission), Beaumont and Beeville; 1 premise each in Galveston and Laredo; 3 in 406 premises inspected in Brownsville; and 9 percent and 12 percent, respectively, in Houston and San Antonio.

As pointed out above, taken by themselves, and particularly as compared with the full-season, city-wide breeding indexes of 1945, these high figures, particularly in Houston, are misleading. We believe that the *Aedes aegypti* breeding index is well below the danger point (estimated at 5 percent) where yellow fever or dengue could cause serious epidemics if introduced, in all Texas cities with the possible exception of San Antonio. This has occurred without any special city-wide efforts at control for the last ten years, and the evidence available indicates that the situation is likely to stay that way. We believe that the principal factor in bringing this about has been the eradication of the great majority of mother foci, and the failure of *Aedes aegypti* to persist in secondary ones in the alternating warm and cold climate of southern Texas. Education undoubtedly has also contributed, by making so many people conscious of *aegypti*-breeding places in protected places in their homes—in water-plant containers, sumps, etc.,—that not enough of these exist to keep the mosquitoes going. The possible failure of almost complete elimination in San Antonio may be due to the special types of mother foci there, such as shallow wells, drinking water barrels, etc., in parts of the city without piped water supply, and also flooded basements, and exceptionally wide use of indoor water plants.

In retrospect, the findings in our preliminary survey in 1942, in which the widespread presence of *Aedes aegypti* was so closely correlated with the presence of extensive mother foci, should have given us more faith than we had in the ultimate success of our wartime program. And perhaps we were even more successful than we thought we were in ferreting out and eliminating the mother foci. We may look forward to sporadic late-summer outbreaks of *aegypti* breeding, resulting either from accidental introductions from outside, just as once happened in our northern seaports, or perhaps occasionally from unusually extensive survival of these mosquitoes in a particularly favorable winter season. But unless control in still-existing mother foci, such as fire-protective barrels, is relaxed, or extensive new mother foci are developed, I believe we are not likely again to find ourselves in as vulnerable a position with respect to *aegypti*-borne diseases as we were in 1942.

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MOSQUITO-BORNE DISEASES IN TEXAS

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In this report I will consider dengue, yellow fever, malaria and encephalitis, the principal mosquito-borne diseases which have been of public health importance in Texas.

The last outbreak of dengue fever in Texas was in 1941, when several thousand cases occurred in the Lower Rio Grande Valley. Cases occurred as far up as the vicinity of Laredo, Alice, and Corpus Christi. Approximately 100 cases of dengue were reported to Texas physicians the following year, but as nearly all these cases occurred in January and February it would seem most likely that some other disease was mistaken for dengue. In more recent years sporadic cases have been reported but it is not believed that any of these were true cases of dengue fever, on basis of occasional laboratory tests. With the appearance of the 1941 outbreak there was considerable hysteria in some parts of the state since many of the older natives remembered that dengue fever had been in times past an unwelcome harbinger of yellow fever. Since *Aedes aegypti,* the mosquito vector, has not been eradicated, the threat of dengue remains; the virus of yellow fever would have to be imported as there is no evidence of the presence of the agent in a Texas reservoir.

It is difficult for us today to realize what a dreadful disease yellow fever once was. Some years ago I uncovered an old unpublished manuscript on yellow fever by the late Dr. J. M. Reuss, Cuero, Texas. Dr. Reuss wrote of the difficulty in distinguishing yellow fever or "black vomit" from severe types of dengue or malaria. He described the "black vomit" of yellow fever as copious and serous with epithelial flakes floating on it; he said it also had a sweet taste and smell. In other diseases the "black vomit" was more mucoid and tinged with black streaks. Dr. Reuss said that he considered the copious perspiration and the pronounced yellow fever smell even more characteristic than the "black vomit." He said that quinine was out of the question in treating yellow fever, as it caused furious delirium; he felt sure that the use of quinine had caused many deaths. Dr. Reuss told of the dead lying unburied, since the well had fled and only the sick remained, during an outbreak at Indianola. Dr. Reuss saw cases of yellow fever at Cuero as late as 1905.

In his official report for 1902, the State Health Officer wrote "In 1900 the Chief Surgeon of the United States Army in Cuba appointed a commission to determine the true cause of yellow fever. In 1901 Surgeon Ross made similar experiments and the conclusions of both were that yellow fever is not conveyed by fomites. . . . I cannot accept these conclusions. . . . I agree that the mosquito *can* convey the disease, but I do not concede that it is the sole distributor thereof."

The reports of the early Texas State Health Officers were replete with details of quarantines against New Orleans and other cities of Louisiana as well as Mexico, in combatting yellow fever. Indeed, Texas cities and counties frequently imposed "shot gun" quarantines against each other. One of the last and most distressing was the Nueces county quarantine against Duval county which impeded the use of the Texas-Mexican railway in shipping food and medical supplies from Corpus Christi to Laredo where yellow fever was rampant in the summer of 1903. When Laredo was quarantined a large part of the populace became obsessed with the idea that the physicians and the authorities were in a conspiracy to extort money. In fact, the State Health Officer in his official report to the Governor wrote, "They went even further and it was generally believed that the physicians poisoned their patients —to end the epidemic. Patients not only

refused treatment but—refused to permit use of a clinical thermometer, thinking this too was poisoned. This was certainly an amazing state of affairs, and it was difficult to believe that such perversion and gross ignorance could exist within the confines of the Republic." One thousand fifty-one yellow fever cases with 103 deaths were recorded in the outbreak at Laredo. The Governor of Texas at the request of the State Health Officer even imposed a quarantine on San Antonio where 36 cases and 18 deaths were reported and many more were rumored.

Some years ago when I was spending much of my time examining thick blood films for malaria, I would not have believed that I would be an eye witness to the virtual extinction of malaria in the U. S. In fact, practically the only focus which remains is in the Lower Rio Grande Valley of Texas along the Mexican border. Only two cases (both *P. vivax*) were diagnosed in the San Benito Regional Laboratory of the State Health Department last year. Perhaps three or four additional cases were diagnosed by physicians in other laboratories of the Lower Valley, but it is uncertain that any of these infections were acquired on the U. S. side of the river. No doubt many factors have contributed in recent years to the decline of malaria and evidently these factors have concerned the parasite, the anopheline vector and human host. As long as the *Anopheles quadrimaculatus* remains in our midst, the threat of malaria cannot be entirely dismissed. This would particularly be true in time of war or disaster.

Outbreaks of "sleeping sickness" or encephalomyelitis in equines wrought great havoc on the farms and ranches of Texas in years gone by. It had been presumed that the infections were all of the western type until 1941 when the eastern type virus was recovered and identified in South Texas. When it became evident that both equine types and St. Louis encephalitis virus were present in South Texas a cooperative research project was set up by the State Health Department and the University of California in the Rio Grande Valley at San Benito. Several thousand mosquitoes were taken and identified in 1942 and later tested for virus. This was particularly a poor year, evidently because none of the viruses were recovered. It should be mentioned in passing that several of these mosquito pools were tested for polio virus. Relatively few of the mosquitoes taken were *Culex tarsalis* which was believed to be the principal vector of encephalitis. Occasional widely scattered cases of St. Louis or western equine infection in man were confirmed by laboratory tests during the next few years. In 1952 when several human cases of encephalitis occurred in the Texas South Plains area, a special project was undertaken by the State Health Department and the Communicable Disease Center. Some of these cases were confirmed as western type infections on the basis of the complement fixation test. A preliminary survey of the mosquito population and the factors involved in their production was made in the Lubbock-Plainview area in August and October, 1953, but a virus was not recovered from any of the mosquitoes collected. The study was continued in 1954 when western equine virus was recovered from two pools of *Culex tarsalis* in the Plainview area and one pool each of *C. tarsalis* and *quinquefasciatus* in the Lubbock area. In this general area 23 human infections due to the western virus were confirmed by the complement fixation test during the three year period, 1952 to 1954. In addition, in 1954 ten cases of St. Louis encephalitis were confirmed. It seems likely that some of the St. Louis cases were not confirmed because of inexperience and unexpected difficulties with the laboratory test. A considerable outbreak of St. Louis encephalitis occurred in the Lower Rio Grande Valley, particularly in Hidalgo county, in the summer and fall of 1954. St. Louis encephalitis virus was recovered repeatedly from pools of *Culex quinquefasciatus* during and once after the outbreak. St. Louis virus was recovered from brain tissue of one of the fatal cases, and a considerable number of cases were con-

firmed by complement fixation tests. A few scattered cases of St. Louis and western type infections also occurred in Texas in 1955. While there has been evidence of eastern type virus activity, at least in Southeast Texas, there has been little or no evidence of human infection in recent years. Although many of the proved infections have been mild, it should be pointed out that mosquito-borne viral encephalitis frequently is a very serious disease. Mortality has been confined almost solely to older people.

In view of the many viruses which have been recovered from mosquitoes in recent years in various countries, it should not be surprising if a fourth mosquito-borne viral encephalitis would be uncovered in Texas.

Also, in view of the newer knowledge of the importance of viremias in the pathogenesis of many of the virus diseases, one should not overlook the possibility that some of our poorly understood viral diseases are mosquito-borne. At any rate, I should like to instill in the minds of the younger men that great discoveries in the field of mosquito-borne diseases remain to be made.

A METHOD FOR MAKING A SURVEY OF FLOODWATER MOSQUITOES [1]

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Populations of floodwater mosquitoes and those of grasshoppers have so many characteristics in common that similar methods for forecasting them may be used. The egg is the only stage in which populations of both are concentrated and stable. Eggs are present for the greater part of the year in recognizable, concentrated sites, but later stages, and especially adults, disperse widely over feeding sites. Observers of grasshoppers have found that data on distribution of eggs are the most reliable for forecasting abundance. Means for examining vast areas of the prairies and plains of central U. S. for eggs of grasshoppers have been devised (Shotwell, 1935), and plans for combatting outbreaks on the basis of data obtained have been made for 2 decades. Supplementary surveys of nymphs and adults affect local changes in the general plan.

Data on populations of floodwater mosquitoes (*Psorophora* and *Aedes*), like those for grasshoppers, indicate that plans for abatement may be made from surveys of eggs, supplemented by observations on the distribution of larvae and adults. The problem is to devise a rapid, dependable procedure for finding and identifying the eggs. Eggs are restricted in their distribution to areas subject to transient inundation. They are further restricted in all but a few instances to portions of shaded areas bearing plant debris, such as lodged plants, masses of algae or leaf mold. Some eggs are on the soil below the plant debris; others are in the debris itself, and still others may be found plastered to the walls of cracks in the soil or holes made by crayfish. They are present throughout most of the year and are always present in fall, winter and early spring. Once sites are known, mechanics of obtaining samples bearing eggs are simple. Identi-

[1] Contribution from the Department of Entomology, University of Illinois.

Funds for support of the investigation were provided by the U. S. Public Health Service.

[2] Assistance of the following persons is gratefully acknowledged: Mr. A. S. Wilson, Dr. R. F. Harwood, Dr. George B. Craig, Mr. Jacques Bergér and Mr. Manfred Engelmann.

fication, too, is rapid and dependable (Horsfall, *et al.*, 1952 and Horsfall and Craig, *in press*). Supplementary surveys of larvae and adults may be used for short term forecasts in abatement operations.

Sampling.—Surveys for eggs may be used for determination of general distribution or for comparison between sites as to productivity. In preliminary stages of a survey, the former is the objective and permits extensive coverage because few samples need be taken from any site. Detailed comparative data require more extensive sampling of each site. Samples should be taken from all zones representing sites for oviposition. Numerous contiguous or spaced samples should be taken along profiles extending from the line of maximum flood to that lowest in the depression.

The equipment needed is simple and readily portable. Where samples are to be taken above the water table, the minimum equipment necessary is (1) a pointing trowel 4–5 inches long having sharp edges, (2) a board 6 inches square (¼ ft.^{2}), and (3) a supply of bags of plain brown paper or those called garbage bags. Samples from submerged sites may be taken with the following: (1) a pointing trowel, (2) a cutting square, and (3) a flat spade. The "cutting square" is much like a large cookie cutter. The cutting edge is a metal band forming a hollow square 6 inches on a side and closed at the top. For convenience a handle attached to the wooden face makes manipulation somewhat easier.

Samples suspected of bearing eggs may be obtained as follows: When dry samples are to be taken, the square is placed on the surface debris and outlined with a pointing trowel by cutting to a depth of about 1 inch into the soil. The sample is then cut loose from the soil below and placed in a paper bag properly marked for site and location. Sampling below water involves use of the "cutting square." The sharp edge of the cutter is put in place and forced into the soil. The spade or trowel is forced beneath the sample while the cutter is in place. The cutter, sample and spade are lifted out of the water together.

Separation of eggs takes place in the laboratory. Samples brought from the field are stored in a cold room or household refrigerator for holding. The act of separation involves 3 stages. Large debris is removed by washing and screening. Heavy material such as soil is separated by sedimentation. Eggs are collected from the last bit of debris by optical means.

Screening.—The apparatus for breaking up a sample and removing most debris consists of 2 parts: (1) a water bath in which a set of 3 concentric cylindrical screens is partially immersed and (2) a set of 3 nested screens one above the other (Pl. I, fig. B). The cylindrical screens in the water bath are bolted together to form a unit as shown in Pl. 1, fig. F. The mesh of the cylinders decreases from inner to outer in the ratio of 4, 8 and 16 meshes to the inch. The whole set is closed at each end by metal caps perforated for a central shaft. The shaft of the cylinder fits into two bearings at each end of the vat (fig. E). The vat holds about 5 gallons of water obtained from a flush tank (fig. A). The nested or superimposed screens are shown in the lower part of fig. B and in detail in fig. D. Each screen forms the flat bottom of a truncated cone of galvanized metal. In order from top to bottom the screens have 40, 60 and 100 meshes to the inch. Each screen can be removed from a stand that can be turned in the manner of a revolving door. A large rubber tube with a pinch valve serves to drain the vat into the nested screens.

The operation of the device is as follows: Single samples are placed into the inner screen of the concentric set, the cylinder is closed, and the whole is placed in the vat. The vat is filled with water from the flush tank. By means of the crank the cylinder of screens is rotated at a rate of about 50 r.p.m. for a total of 125 revolutions. In practice, rotation is first 25 turns in one direction, then 25 turns in reverse until the sequence is complete. While completing the last 25 turns, the

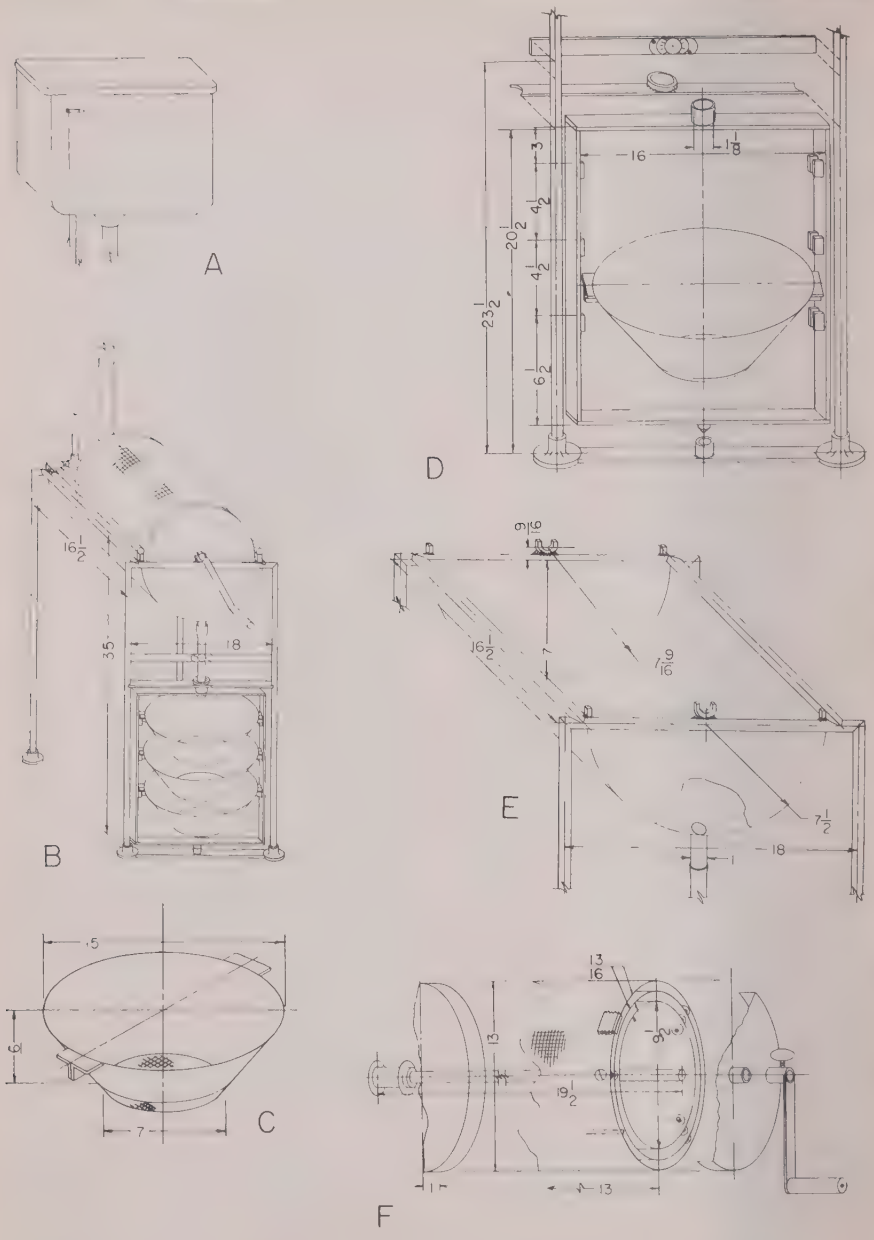

PLATE I. Illinois Mosquito Egg Separator

Fig. A. Flush tank
Fig. B. Assembled separator
Fig. C. Cone sieve
Fig. D. Cone sieve assembly
Fig. E. Detail of water bath
Fig. F. Detail of cylindrical screen assembly

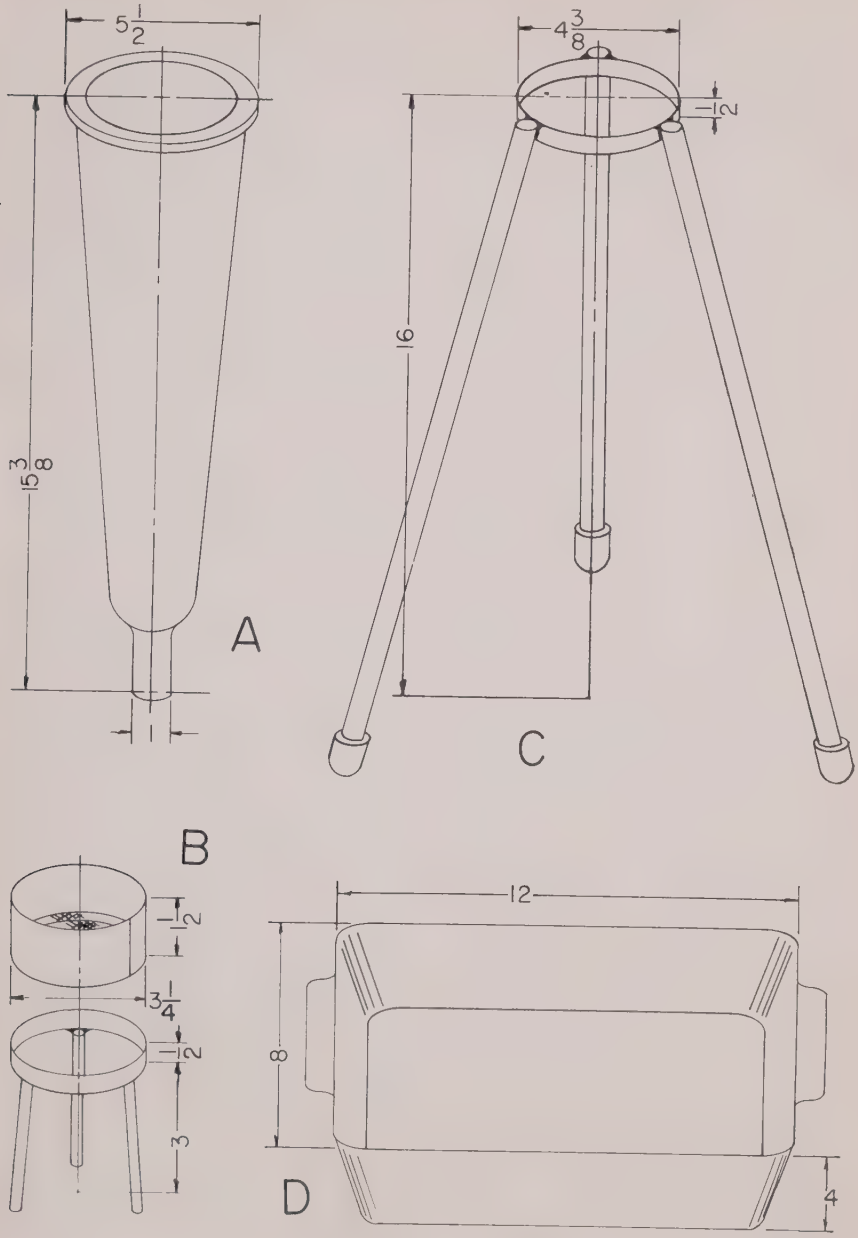

PLATE II. Apparatus for Flotation

Fig. A. Percolation funnel
Fig. B. Transfer screen assembly
Fig. C. Stand for percolation funnel
Fig. D. Plastic pan

vat is drained through the rubber port into the top screen below. As the vat is drained jets of water are sprayed over the turning cylinders. The jets come from a row of holes in a pipe along each side of the top of the vat as shown in Pl. I, fig. B. A treadle valve permits an operator to flush out the vat and keep both hands free. Debris collected on the various nested screens is subjected to a fan-shaped jet of water from a nozzle so as to wash eggs through to the bottom screen. Only silt and the finest debris pass through the bottom screen. All eggs are retained. Eggs and associated debris are washed from the bottom screen to a transfer screen (Pl. II, fig. B) for temporary storage.

FLOTATION.—Further separation of eggs from debris is based on differential densities and may be done in saturated solutions of technical NaCl in tap water. Equipment needed includes (1) percolation funnel (2-liter capacity) and stand (Pl. II, fig. A and C), (2) air pump, (3) casserole (150 ml. capacity), (4) plastic pans (Plate II, fig. D) and (5) wash bottle. An air pump such as is used in aeration of aquaria is suitable.

Flotation is accomplished in 2 stages. During the first the sample from the transfer screen is rinsed into a stoppered percolation funnel containing about 1½ liters of saturated salt solution. The solution is stirred by means of a long glass tube through which air is passed from the pump. After stirring for a minute or two, the bubbling-stirrer is removed and the contents of the funnel are allowed to stratify. The eggs together with a small amount of debris will float to the top while most debris will settle. A few minutes later heavier debris at the bottom is drained through the hole in the base (Pl. II, fig. A). Remaining material that is floating and trapped along the walls of the funnel contains the eggs. It is collected in a transfer screen.

The collection on the transfer screen is then rinsed into a casserole with tap water. At the option of the technician this collection may be treated to a second flotation directly or may be stored in a cold box at about 4° C. for an hour or overnight. Whichever course is followed the floating debris and most of the water are decanted as waste, and the residue is flooded with the saturated salt solution. Eggs and the small amount of debris will float as a layer on top of the solution. This layer is decanted into a transfer screen and rinsed into another casserole with tap water.

Optical separation is the final act and is carried out in 2 stages. During the first, eggs are removed from the last bits of debris, and during the last stage, they are separated according to species. For the first phase the operator needs a stereomicroscope with a wide field and a resolving power of about 10 diameters. Accessory equipment includes small casseroles, dropping pipets and a wash bottle. Residue from the final flotation is examined in a casserole containing about 30 ml. of water. Eggs or debris are removed by means of a dropping pipet. The cleaned eggs are now ready for identification. A stereomicroscope with a resolving power of about 100–130 diameters as well as a black, non-reflective, shallow container holding water are necessary. Depressions in a spot plate coated with black, plastic electricians' tape are suitable containers. Eggs may be separated as to species from a mass of some 50–200 eggs. Then the eggs may be transferred to a casserole for counting.

STORAGE.—Eggs may be kept for future use either in a preserved or in a fresh state. In the former instance a solution of 10 percent formalin is satisfactory. Live eggs may be kept on moist filter paper in a moist chamber at room temperature for short intervals or in a household refrigerator when storage for longer time is required. They may be stored in water for long periods if the water is kept well aerated.

EVALUATION.—The technique outlined above is a dependable means for separating eggs by experienced technicians in this laboratory. On one occasion such a technician placed 100 eggs in each of 5 samples known to be free of any eggs of the test species. The rate of recovery was

between 81 and 89 percent. Another series of 5 samples was populated with only 1 egg each. The single egg was recovered from four of the 5 samples.

SUMMARY.—A dependable means for making surveys of floodwater mosquitoes based on sampling for eggs has been devised. It consists essentially of collecting samples of surface debris, bringing them to the laboratory, screening them, floating the residue and finally identifying the eggs microscopically.

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SALT-MARSH MOSQUITO CONTROL IN NORTH CAROLINA DURING 1955

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Several factors that are not applicable to most of the states represented here have influenced the type and extent of mosquito control in North Carolina.

In many states where extensive salt-marsh mosquito control has been carried on for years, the incidence of malaria has been too low to require control operations comparable to those necessary where this disease constituted a major problem. While many of you were developing large scale programs directed at making the environment more conducive to comfort and good living, we were struggling to protect the health and lives of our people. Most mosquito control facilities available on a state wide basis were directed at *Anopheles quadrimaculatus*. Some local communities, however, did conduct pest mosquito control in a small way.

Another influential factor is the topography of our state. The Outer Banks, which is the name generally applied to the string of islands along the entire seaboard, being a barrier to navigation, retarded the early settlement and development of the coastal region. While populations were growing and cities being built along the coast in other states that border the ocean, our growth was taking place farther inland. Changes are now apparent and something akin to an economic renaissance is going on in the eastern counties. The tourist business is booming and new recreational facilities are provided every year. Soil reclamation by drainage and recently discovered techniques in farming, as well as animal husbandry, are bringing about increased participation and productivity in the field of agriculture. New industries are moving in while others are exploring the suitability of the region for their types of operations. There is still considerable disproportion between the counties affected by salt-marsh mosquitoes and the rest of the state with regard to population densities and economic status. A recent com-

pilation of data revealed that these counties comprise 20.0 percent of the land area but have only 10.3 percent of the population. The variation in sources of taxation is equally great.

Now that our principal concern with malaria is the prevention of reintroduction rather than the application of control measures in areas of high endemicity, we have time and facilities to devote to pest mosquitoes.

The 1955 General Assembly passed legislation which created the North Carolina Salt Marsh Mosquito Study Commission. There are seven members, four of whom were appointed by the Governor, one is a representative of the State Board of Health, one a representative of the Department of Conservation and Development and one a representative of the Wildlife Resources Commission. The duty of this Commission is to make a study of salt-marsh mosquito problems in eastern North Carolina, investigate the capacity of each county, town and city to provide funds for control operations, and make a report of its findings, along with recommendations, to the Governor, to be transmitted by him to the next meeting of the General Assembly. A sum of $15,000.00 was provided for expenses incurred in accomplishing the purpose for which it was created.

Embodied in the act is a provision whereby the Governor and Council of State are authorized to allocate from the Contingency and Emergency Fund amounts found reasonably necessary to provide for control of mosquitoes until the 1957 Legislature convenes.

Immediately following the formation of the Commission, help was sought and obtained from the U. S. Public Health Service in making a preliminary survey of the salt-marsh mosquito problem along our coast. The official who assisted us in this survey estimated that a minimum of $500,000.00 per year would be required to obtain satisfactory protection from salt-marsh mosquitoes. He also emphasized the need for research in breeding, flying and biting habits of these mosquitoes as well as the development of more effective control methods.

The Governor and Council of State allocated $15,000.00 from the Contingency and Emergency Fund for control operations and authorized the Commission to spend the $15,000.00 appropriated with the assurance that additional funds would be provided for continuing the study. We were instructed to use these funds to help those who help themselves.

A questionnaire was prepared and sent to counties, towns, and other community organizations in the coastal areas, in which information was sought concerning the willingness and ability of each community to participate financially in mosquito control. Initial information obtained from these questionnaires revealed a willingness on the part of the communities to spend slightly over $40,000.00. The amount actually spent by them was greatly increased, however, as the season progressed.

With such a small amount of money, we were were faced with the problem of determining how it could be spent to obtain maximum benefits. Consistent with the policy of helping those who help themselves, a rule was followed whereby insecticide materials would be given communities that purchased or already possessed dispersal equipment, and in some instances the equipment was rented by us for use in communities that preferred to furnish the insecticides. In less than a month, most of our funds were either spent or encumbered.

After the hurricanes Connie, Diane and Ione passed through the State, the Federal Civil Defense Agency determined that the vast increase in salt-marsh mosquitoes was a result of these hurricanes and made mosquito control funds available in the affected areas. Help in the amount of approximately $200,000.00 was obtained from that Agency for adulticiding, and projects in excess of that amount have been approved for the restoration of drainage systems to the condition they were in prior to the hurricanes.

Our long range plan involves the elimi-

nation of salt-marsh mosquito breeding areas of drainage, filling, diking, or other measures but we do not have facilities for successfully undertaking this type of operation now or in the immediate future. With the scanty funds available, lack of trained supervisory personnel, and limited knowledge with regard to the mosquito breeding areas, it was deemed advisable during the season's operations to apply the major part of our effort toward killing adult mosquitoes.

The communities employed thirty-five ground space spray machines of either the mist or fogging type for the dispersal of adulticides and the people on one of the beaches purchased an airplane. The latter was used for both larviciding and adulticiding. Other aircraft acquired on a contractual basis consumed 180 flying hours in the application of larvicides. The U. S. Public Health Service helped during the disaster by providing engineering personnel to assist in the preparation of Federal Civil Defense Agency project, supervision of operations, and evaluation of results. This Agency also lent us four space spray machines and one aircraft and furnished 7500 gallons of pesticides. Throughout the whole operation, DDT in various formulations was the only insecticide used.

The urgency of the problem made it necessary that practically all resources be applied to actual control operations, thus precluding the opportunity to gather entomological or other data to the desired extent for evaluating the effectiveness of results. Observations of mosquito densities in areas before and after the dispersal of pesticides, talks with local officials, as well as other residents, and letters received show that the results were governed by frequency of dispersal, amount and type of supervision given, weather conditions, topographical features, and skill of the operator. Where nightly coverage was given, with other conditions favorable, excellent control was obtained.

With no legislative appropriation for the coming season, operations will again be dependent upon funds given us from the Contingency and Emergency Fund. It is not anticipated that enough money will be available to justify a modification in the type of operations. Again we will concentrate on killing adult mosquitoes where the people are. It is hoped, however, that the 1957 General Assembly will appropriate a sizeable sum and enact legislation that will provide for the formation of mosquito control districts similar to those in other states.

MOSQUITO PROBLEMS IN ALABAMA

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Alabama's mosquito problems are perhaps not as extensive nor as important economically as those of some of the adjoining states. Local situations of high mosquito densities are frequently experienced, however, and a great diversity of breeding conditions and mosquito species complicates the picture. Within the rather complex picture can be discerned a few typical patterns which are worth considering by those involved in mosquito control.

For many years health authorities were concerned primarily with *Anopheles quadrimaculatus,* since malaria was a major disease problem in the state. Malaria transmission is now non-existent. It is not within the province of this paper to try to evaluate the contribution of the

various control efforts made over the years, including the extensive DDT residual house spraying program, to the eradication of malaria. It should be noted however, that heavy populations of *Anopheles quadrimaculatus* still exist seasonally in some of the areas which were formerly malarious, notably along the Tombigbee, Warrior and Alabama Rivers.

Alabama was a leader in the development of *Anopheles* prevention and control methods on impounded waters. In 1923 the State Board of Health adopted regulations pertaining to man-made lakes, setting forth definite requirements as to construction of dams, preparation of reservoir areas, and making the owners responsible for the prevention or control of *Anopheles* breeding. Without such measures malaria would undoubtedly have spread geographically within the state and malaria eradication would probably have been delayed. These regulations with some modifications are still in effect. There are approximately 9,000 impoundages on record with the State Health Department, ranging in size from 0.1 acre to 67,000 acres. The estimated total area of farm ponds in the state is 55,000 acres. There are approximately 242,000 acres in large impoundments. At the present time there are two major impoundments under construction and nine others in final stages of planning. Three of these will serve to complete the development of the Chattahoochee River and five of them will complete the development of the Coosa River. The other three are located on the Warrior and Tombigbee system. Ultimately it is planned to construct additional dams on the Alabama and Tombigbee which will completely harness these streams for purposes of navigation, power generation and flood control.

The owners of artificial lakes are legally responsible for the prevention or control of *Anopheles quadrimaculatus* breeding in their lakes. In most instances mosquito control activities by the owners of major impoundages have fully satisfied and exceeded this responsibility. The vast amount of research conducted in Alabama related to the production of mosquitoes in impounded waters is well-known. Equally well-known is the development and practical application of various naturalistic control measures, water level management specifically for mosquito prevention, permanent shore line alterations, and the correlation of these methods with fish and wildlife interests. Lake owners, already equipped for *Anopheles* control, frequently carry out temporary anti-mosquito operations against *Aedes* and *Psorophora* mosquitoes which may be produced when flood control policies require that surcharges be maintained for a time. Such operations are not required legally, but have proved to be good public relations investments.

The salt-marsh species, *Aedes sollicitans* and *Aedes taeniorhynchus,* are troublesome only in portions of two counties, Baldwin and Mobile. The coastal portion of Mobile County is relatively undeveloped tourist-wise, but following the opening a few months ago of the Dauphin Island bridge, that island is being developed rapidly. Fortunately, invasions of the City of Mobile by large numbers of salt-marsh mosquitoes are rare. The coastal portion of Baldwin County is developing rapidly as a resort. This area is plagued by salt-marsh mosquitoes intermittently. Large numbers of fresh-water woodland mosquitoes, particularly *Aedes atlanticus,* and *Culiseta inornata* are also found in this area, frequently predominating within a mile of the beach.

An interesting extension of the salt-marsh mosquito problem consists of the development in 1954 of a focus of breeding for *Aedes sollicitans* and *Aedes taeniorhynchus* at McIntosh, about 40 miles north of the City of Mobile. In the development of several large salt-water wells by a chemical plant, large quantities of highly saline water were pumped to waste, and flooded for several weeks a wooded depression. Heavy breeding of both salt-marsh species occurred. The following year breeding recurred in rain water which filled these

depressions. As far as we know, no salt-marsh mosquitoes had ever been observed in this area before. This development, and the establishment of *Aedes sollicitans* breeding in a mining region of Kentucky have led to some speculation as to the possibility of further inland invasions in Alabama.

There is no legislation designed to facilitate the organization of abatement districts or to provide financial assistance. It is obvious, however, that as the coastal areas develop there will be an increasingly strong demand for mosquito control in these areas. There is a need for additional study to determine the most effective and economical means of controlling the mosquitoes prevalent near the coast to avoid costly mistakes when financial and administrative means for control become available.

Inland, the vast majority of our towns and cities have mosquito problems of varying intensity due largely to the breeding of *Culex quinquefasciatus* in ditches, especially polluted ones, and in artificial containers. *Aedes aegypti* are also frequently found breeding in artificial containers along with *Culex*. *Aedes aegypti* appears to be confined to urban areas in the central and northern part of the state, but may be found both in towns and in rural areas in the extreme south. A survey conducted in Birmingham, Montgomery and Mobile in 1952 showed significant *Aedes aegypti* breeding in all three cities, with the highest premises index (20%) in Mobile. Most cities are making progress toward the elimination of sewage-polluted water in open ditches, but wherever this condition still exists, it assures heavy and concentrated breeding of *Culex* mosquitoes. During the late summer of 1954 (one of the driest seasons on record) a number of towns experienced unusually large numbers of *Culex* mosquitoes, emerging from very small areas of highly polluted water. In such situations we recommend larviciding and as soon as possible the elimination of breeding waters.

Approximately 30 cities in the state carry on seasonal larviciding routinely. Fourteen do adulticiding by means of mist or fog machines. Fogging has a strong popular appeal and in a number of instances has been employed in situations where better results could have been achieved at much less cost by larviciding.

Other mosquito problems, usually of short duration and limited extent, deserve mention. It is normal to have fairly heavy broods of several species of *Aedes* and *Psorophora* mosquitoes in early spring in the swamps along the major streams. Subsequent broods may emerge if heavy rains or floods occur during the summer, although the latter condition has not arisen for the past several dry years. Occasionally there seems to occur an unusually heavy breeding season for these woodland pool and flood-water mosquitoes. Such a season was the early part of 1955. Along the lower Tombigbee and Alabama Rivers, a tremendous brood of *Aedes sticticus* appeared in March. A record-breaking late freeze occurred in April, reducing the *sticticus* population considerably. About two weeks after the freeze there emerged great numbers of *Aedes vexans, Aedes infirmatus, Psorophora cyanescens,* and smaller numbers of other species. For a period of several weeks this situation caused severe complaints from farmers in the vicinity, after which the mosquitoes gradually died out. We have no practical solution for such problems as they affect rural areas. In the few instances where municipalities are affected, adulticiding by fogging, as was done by the City of Demopolis, is economically feasible and reasonably effective.

Broods of *Psorophora* also emerge following heavy spring or summer rains in other parts of the State, particularly through the "Black Belt," and in the limesink areas of the Tennessee Valley. The southern suburbs of Montgomery, for instance, frequently have short-term scourges. Where communities of sufficient financial resources are affected, fogging is the only recourse. Fortunately these broods usually dissipate within a week or so.

THE PROGRESS OF MOSQUITO CONTROL IN NEW YORK AND NEW ENGLAND

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NEW YORK (Partial report; many areas not included).—According to a report by Mr. Leroy Kinsey of the Nassau County Mosquito Control Division, the activities in Nassau County are more or less the same from year to year. Basically the methods remain the same: the No. 1 item is still drainage, with chemical control as No. 2, and adult control as their No. 3 method.

Of course, new tools are being added from time to time. At present the "Scavel Plow" which was developed in Connecticut, is being used in cleaning the salt marsh drainage ditches. Through experience they found it necessary to purchase tractors with greater horsepower in order to cut down lost hours due to mechanical failures caused by overtaxing the smaller type machines. They have changed from the Oliver Model OC3 to Oliver OC6. After making the change, it was found that the loader mechanism used on the smaller tractor was not heavy enough to withstand the power of the new machine. Then started a search for a suitable attachment capable of withstanding the power, as well as satisfactorily handling the scavel itself. Through one of the local equipment distributors they were able to get a dozer attachment manufactured by the A. C. Anderson Company of Wildwood, N. J. which meets the requirements. At present they have two machines equipped with this attachment and find they work very satisfactorily. The scavel can be removed and a back-filler or bulldozer blade may be substituted if desired.

In their chemical control program it was found cheaper to make up their own larvicides. During the past season a stable water emulsion was used for field spraying. The larvicide was developed by one of the employees and has proven successful and economical to use.

The adult program is used only in areas where heavy infestation has occurred. They do not fog at night, and find that psychologically the residents are pleased with the system of fogging during the day. Using this method, the traffic hazards are not as great, and more people are cognizant of the activities of the department. There are those in mosquito control work who disagree with this theory, as expounded by Mr. Kinsey, but the results obtained in the county speak for themselves.

MAINE.—Maine has no definite, organized mosquito control set-up, probably due to lack of funds. There has been a statute on the books since 1929 authorizing the State Entomologist to cooperate with the Department of Health in suppressing mosquito nuisances.

Species surveys have been conducted. Many small local projects, particularly along the coast, are financed by private contributions. The oldest project in Maine is probably the one near Popham Beach, carried on by Mr. Cushman of Portland.

Through the use of WPA funds, an extensive drainage project was carried on at Old Orchard in 1932. This area has since been filled in and now serves as a parking lot.

NEW HAMPSHIRE.—As reported by Dr. J. G. Conklin, State Entomologist, New Hampshire has no organized program or department for mosquito control. There are a few recreational and seacoast areas which carry on private programs.

On February 1 a meeting was to be held by the Seacoast Regional Development Association intended to create sufficient interest in mosquito control so that

possibly a bill may be introduced at the next legislative session to pass some sort of enabling act to make possible the creation of a mosquito abatement district.

Vermont.—The mosquito control problem in Vermont is mostly restricted to the spring flood water types of mosquito, on occasions when heavy rains prevail and large streams and rivers overflow.

There is no early record of any work done in Vermont for mosquito control. According to Mr. John W. Scott, Director of Plant Pest Control, prior to and during World War II, one town—Brandon—and a summer resort area—Lake Dunmore—used to place sawdust-filled bags soaked with oil in the swamps and spring-flooded water holes found in the general vicinity of the town and the lake. In 1945, VJ Day to be exact, Chris Williamson and Ken Tyler flew up to the Lake Dunmore region and sprayed DDT by aircraft around the lake for mosquito relief. The state at that time was in no position to recommend a particular control measure using DDT, which was relatively new for civilian use, and no action was taken. In 1947 the Legislature provided for surveys and recommendations for interested communities and groups desiring to formulate mosquito control programs. For this reason, Mr. Scott was brought to Vermont. Surveys were made in a number of the worst mosquito annoyance areas in the state. Most of the recommendations were based on dust control because almost all of the areas suffering from mosquitoes were much too large for the population to support a more permanent type of control. In one instance a soil conservation project was developed in which a good-sized swamp was drained and mosquito relief was thereby obtained.

At the present time the mosquito control work is being conducted by space spraying using DDT. One town has a mist machine, and a resort area has a mist machine and a fogging machine. A few communities have obtained the services of tree operators using mist machines to gain control of mosquitoes in the adult stage. One village is contemplating the use of pre-hatch treatment in flooded areas around the village, for which Mr. Scott and his crew will conduct a survey this coming spring.

Massachusetts (as reported by Robert L. Armstrong).—The hurricane rains in late August produced one of the greatest late summer broods of mosquitoes ever experienced in southern New England. *Aedes canadensis* constituted a much larger proportion of the species than is normally expected in a summer brood.

There were extensive areas sprayed by aircraft in late April and May. It had the effect of almost completely eliminating the spring brood of mosquitoes.

Two new areas are being surveyed as possible mosquito control districts—Bristol and Norfolk Counties, exclusive of the towns presently in the South Shore and East Middlesex Mosquito Control Projects.

Commercial aircraft services do mosquito control spraying in more than 100 individual towns outside of the several mosquito control districts.

South Shore Mosquito Control Project has put into operation a tractor with a "Scavel Plow," modeled after the Connecticut machine.

Bill Doane, of the Cape Cod Mosquito Control Project, reports good results with TELVAR herbicide on aquatic vegetation in a flowing stream.

The East Middlesex Mosquito Control Project has adopted a Titanium Oxide spray as an aid to observing mosquito breeding in catch basins.

Connecticut (as reported by Julius Elston, Chief of Mosquito Control).—Organized mosquito control has been carried on in Connecticut since 1915. The pioneers who brought this about were Director E. H. Jenkins and State Entomologists W. E. Britton and B. H. Welden of the Connecticut Agricultural Experiment Station.

At first, all costs were borne by the towns and interested parties. As time went on, the enabling act was changed or amended as the need arose. In 1949, employees of the State Board of Mosquito Control, under the leadership of Super-

intendent R. C. Botsford, developed a ditch-cleaning machine called the "Scavel Plow" which can clean approximately 100 feet of standard size ditches per minute. This plow has been widely accepted, now being used in New York, New Jersey, Delaware, Massachusetts, and other states.

In 1951, under a state re-organization program, the State Board of Mosquito Control was abolished and all the personnel, properties, and functions were transferred to the State Department of Health, Bureau of Sanitary Engineering.

In 1955 the following was accomplished under their program:

130,000 ft. of ditches were cleaned by hand
100,000 ft. of ditches were cleaned by power
1,000 ft. of new ditches were dug by power
600 hrs. were used in carrying on a hand spraying program
200 hrs. were used in power spraying
1,500 hrs. were spent on inspection work.

The mosquito control appropriation for the current year is approximately $45,000.

RHODE ISLAND.—Mosquito control in Rhode Island has come a long way in the past ten years or so. It was carried on in Newport and the Watch Hill section of Westerly as well as in some areas in Providence, in the early 20's, with a marked degree of success. Then came the middle 30's with ERA, WPA, SUR, and other Federal Agencies which organized and carried on large-scale programs for most of the areas in the state having mosquito problems.

This all reverted back to the state when the Federal Agencies were discontinued, and Milton H. Price was placed in charge. When he resigned in 1945, he was replaced by William V. Bartosewitz who conducted the program until his untimely death in 1952.

In 1947 the statute was amended so that each city or town could apply for reimbursement funds under a state-wide program. At that time, nine towns and four cities were in the program and spent about $7,000. The state spent about $20,000 for this program and for a state crew to do the work on state-owned lands.

I was appointed in early 1953. At the present time we have 20 towns, 7 cities, and 6 private associations under our program of organized mosquito control. This past year approximately $80,000 was spent by these groups and the state spent about $37,000. Some outdoor theatres and other private groups do control work but no report is turned in to this department as no state funds are involved. Therefore, it is safe to say that the entire cost in Rhode Island for the past year for control work was about $125,000.

Our work consists mainly of ditching and draining, with some mist blowing, helicopter spraying, and catch basin spraying. Under our set-up each city or town appropriates a certain sum and the state reimburses them for work completed. No town or city can be allocated more than $3,000 in any one fiscal year or be paid more than one-half of any bill submitted. This year, each city and town was allocated 34 percent of its appropriation.

All work must be approved by the state department and carried out under its supervision and inspection. The state furnishes all technical aid, and the towns furnish labor, equipment, and materials. Close to one million dollars have been spent in the past ten years.

NORTHEASTERN MOSQUITO CONTROL ASSOCIATION.—This group was formed on February 3, 1955, at Amherst, Mass. It comprises New England and New York. On January 19–20 at Waltham, Mass. the second annual meeting was held, and all officers were re-elected to another term. Everyone who attended seemed to feel that this meeting was a successful one. Last May the Association conducted a training course at Amherst for field men and it was so popular that it is to be repeated again next month, both at Amherst and at the University of Rhode Island. Dr. Pratt, of the U.S.P.H.S., will be the instructor.

HAZARDS TO LIVESTOCK OF INSECTICIDES USED IN MOSQUITO CONTROL

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The public has shown considerable suspicion of the activities of scientists engaged in mosquito control. Persons in charge of control projects have, from time to time, been called upon to defend their actions against the accusations of aroused farmers and veterinarians. In most cases the charges were unfair. In spite of the tons of insecticides used against the mosquitoes, there have been virtually no confirmed cases of poisoning of livestock. Why, then, is there constant suspicion? I feel that several factors are responsible. An unfavorable press, putting unreasonable blame on DDT for many of the illnesses of man and animals, aroused the public. A lack, in the early days, of assembled toxicity data gave no defense. Some veterinarians used insecticide poisoning as a diagnosis without proper consideration. Some chemists, unfamiliar with the methods of insecticide analysis, unknowingly reported outlandishly erroneous results.

Actually, mosquito control personnel should be complimented for having realized the hazards and for taking adequate precautions. Without doubt, this was accomplished by a healthy fear of the retribution in store for them if they failed, and by the need for relatively small quantities of insecticides dispersed over wide areas.

I believe difficulties can be avoided completely if you continue to make use of the available toxicity data, keep farmers and veterinarians informed of your proposed applications, work for a favorable press with factual information and train your operators to respect the rights and property of others.

The various dosages of modern insecticides required to produce intoxication of livestock are reasonably well-known and have been compiled in Technical Bulletin 1122 of the U. S. Department of Agriculture.

If we consider only the toxicity of these compounds on a milligram per kilogram basis, we may make the following groupings:

Compounds toxic at 200 mg./kg. or higher doses:

DDT, TDE, methoxychlor, Perthane and Dilan fall in this category. It is my opinion that these compounds will be involved in poisoning only when the grossest carelessness in handling occurs.

Compounds toxic at 25–200 mg./kg.:

This group would include chlordane, toxaphene, Strobane, malathion and Dipterex. These may be considered safe when used with caution, but can cause poisoning with very little carelessness.

Compounds toxic at 0.5–25 mg./kg.:

This group includes Diazinon, parathion, TEPP, EPN, lindane, dieldrin, aldrin, heptachlor, isodrin and endrin. These must be used with utmost caution at all times.

In practical application these apparent hazards are sometimes reversed. A compound, such as parathion used at 0.1 pound/acre and toxic for calves at 0.5 mg./kg., is no more dangerous than some other compound used at 4 pounds/acre and toxic at 20 mg./kg. Toxicity data must be used together with application rates.

The persistence of an insecticide as a residue must also be taken into account. A compound hydrolized in 24 hours represents a different problem from one that persists for several months.

Persistence of residues on forage or in water offers less of a hazard to the livestock than of creating an undesirable residue in the tissues of the animals. We have fed the following insecticides at the indicated levels for 112 days in all their feed with no indication of harmful effect to sheep or cattle: Heptachlor, 2.5, 10 p.p.m.; Dieldrin, 1, 2.5, 10 p.p.m.; Endrin, 2.5, 5.0 p.p.m.; Aldrin, 2.5, 5.0 p.p.m.; BHC, 100 p.p.m.; Lindane, 100 p.p.m.; DDT, 25 p.p.m.; Methoxychlor, 25 p.p.m.; Toxaphene, 25, 100 p.p.m.

SYMPTOMS AND LESIONS

With chlorinated hydrocarbon insecticides such as aldrin, dieldrin, chlordane, heptachlor, toxaphene and Strobane there is usually a delay of 15 minutes to several hours before symptoms appear. The premonitory symptoms are usually hyperexcitability and increased or exaggerated response to external stimuli. Muscular spasms soon follow, involving the facial muscles, then other muscles backward over the body. Convulsions may follow and are tonic-clonic in nature. An animal may suffer one or many convulsions. Death may occur during the first convulsion, or recovery may follow many. During convulsions the body temperature rises to as high as 116° F.

Some animals show only symptoms of depression. Others alternate depression and convulsions or other activity.

Lesions at necropsy are confined to those associated with violent death—parboiled viscera, random hemorrhages and congestion. There are usually some hemorrhages on the heart, which is usually in systole, and excessive cerebrospinal fluid under pressure.

DDT, TDE and methoxychlor produce a different chain of symptoms. They are characterized primarily by tremors which increase in intensity so that the animal shivers violently. Between seizures the animal behaves as though suffering from laminitis, walking carefully and on tip-toe. Seizures may be evoked by sudden external noises and other stimuli. Necropsy lesions are primarily negative.

The organic phosphorus compounds, such as parathion, malathion, Dipterex, TEPP and others produce symptoms by interfering with cholinesterase. These compounds were developed both as insecticides and as chemical warfare agents. The principal symptoms are profuse salivation, dyspnea and a stiff-legged walk. Constriction of the pupils occurs, but is not easy to recognize in sunlight due to the normal constriction. Death is usually due to respiratory failure.

At necropsy there are practically no lesions save edema of the lungs in some cases.

The course of poisoning by this group of compounds is usually short, often only a few hours.

When controversy and accusations occur I would suggest that you proceed somewhat as follows: First, put in writing all the available information on treatments, frequency, number of animals involved, period of exposure, etc., and have the owner and others sign those records as soon as possible. It is good to take pictures, particularly motion pictures, of both the affected and unaffected animals, preferably including the owner and some identifying date. Samples of feed, ingesta and tissues should be obtained, frozen and shipped to qualified chemists. A veterinarian should take specimens for bacteriological or virological study. Finally, be a diplomat to the end. If these suggestions are followed, most disputed cases are settled in a short time.

CONSIDERATION OF HUMAN EXPOSURE TO MALATHION USED IN POPULATED AREAS

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The studies presented here supplement those of C. M. Gjullin [1, 2] during 1954 and 1955 in Merced County, California, and were made to estimate human hazard in the event it becomes necessary to use malathion to combat mosquito vectors of disease in populated areas. Measures of human exposure were obtained by methods developed by various industrial hygienists and by the Communicable Disease Center of the U. S. Public Health Service.[3] The discussion here relates to single exposures to malathion, not to frequently repeated exposures. Exposures in the same order of magnitude repeated at intervals of less than one week might require further consideration since the effects of malathion may be cumulative.

The first figure in Figure 1 shows the exposure of a man standing ten yards downwind from a Husman spray generator applying malathion at the rate of 12 gallons per linear mile.

The second figure shows the exposure of a man working in the open during airplane application of malathion from an altitude of 70 feet at the rate of .46 lb. per acre.

The third figure shows the exposure of a man working in a schoolroom with doors and windows open during airplane application of malathion from an altitude of 70 feet at a rate of .46 lb. per acre.

Amounts of malathion per square centimeter of surface area deposited upon various parts of the body are given with lines pointing to the respective body areas.

It can be seen that outside during airplane application where rather large droplets up to 350 microns in diameter were falling almost vertically, the head and chin gave considerable protection to the front of the neck. Amounts found on the back of the neck were in the order of 1.77 micrograms per cm^2 while on the front of the neck they were about one-fourth of this, or .45 microgram per cm^2. Relatively less protection to the front of the neck resulted from exposure to the smaller, horizontally windborne droplets produced by the Husman generator. In this case .36 microgram per cm^2 was found on the back of the neck, and three-fourths of this amount or .26 microgram per cm^2 was found on the front.

Inside the schoolroom, where probably only particles under 3 microns in diameter were present, the distribution of malathion upon body surfaces was quite uniform, ranging from .25 to .56 microgram per cm^2.

Our measures of body surface deposits thus support the contention that a simple canopy would provide considerable protection to a man working in sprays consisting of large droplets, while commensurate protection for a man working in very fine aerosols would require protective clothing covering nearly his entire body.

Total amounts of insecticide found on exposed skin and total amounts inspired during the entire period of exposure are listed below each figure. We can estimate the amount of protection afforded by the building by comparing the total exposure figures of the man indoors, whose inspiratory and skin exposures were 23.5 and 984 micrograms respectively, with those of the man outdoors during aerial application whose inspiratory and skin exposures were 109.2 and 3,556 micrograms respectively. Roughly, the outdoor exposures were four to five times higher than indoor exposures.

One way to estimate possible hazard from exposure to malathion is to measure blood cholinesterase levels. This was done

* Bureau of Adult Health, California State Department of Public Health.

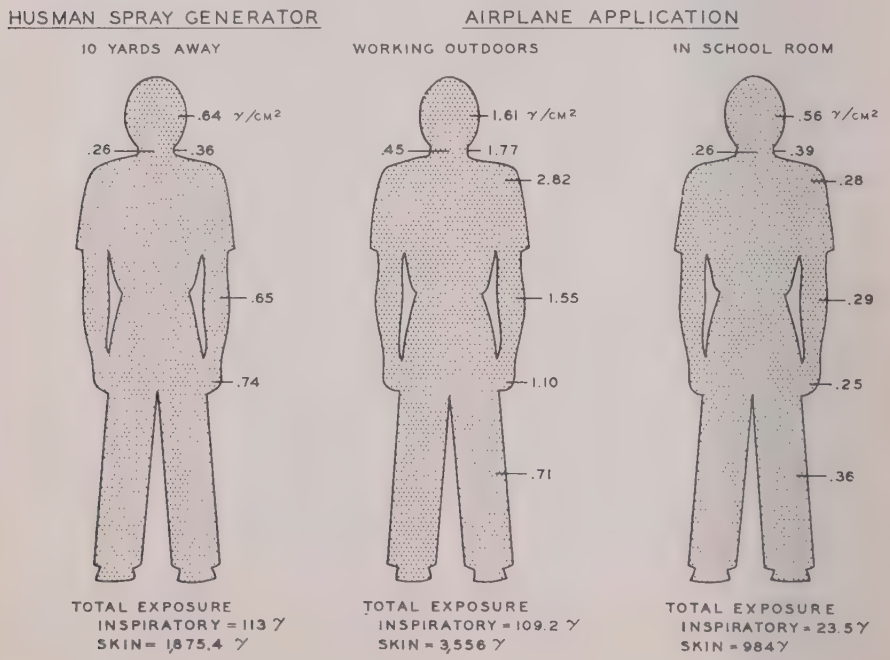
† Division of Laboratories, California State Department of Public Health.

for another man exposed to spray from the Husman generator 23 times during a two-week period.[4] The amounts of malathion averaged 696 micrograms by the inspiratory route and 2,565 micrograms (range 50 to 8,818 μg) on the skin. The cholinesterase activity levels of this man showed no changes due to malathion absorption during the two weeks of exposure. Exposures of the two men during aerial application were not repeated and thus were considerably less than the cumulative exposure of the man repeatedly exposed.

Another means of estimating the amount of hazard involved in a given exposure is to compare that exposure with LD_{50}'s or other measures of animal sensitivity to poisons. Although animals cannot be depended upon always to react to toxins as humans do, such comparisons can often be of value in making very rough estimates of toxicity. Comparison can best be made on a basis of milligrams of insecticide per kilogram of body weight. The highest inspiratory exposure of the three work situations occurred to the man exposed by the Husman generator. This exposure amounts to .01 milligram of malathion per kilogram of body weight. The only animal LD_{50} we have to compare this with is the rat intraperitoneal LD_{50} of 750 milligrams per kilogram.[5] The highest skin exposure of the three work situations also occurred to the man exposed by the Husman generator. His exposure amounted to .13 milligram of malathion per kilogram of body weight. For rabbits, the dermal acute minimum lethal dose is 6,150 milligrams per kilogram.[6] We can see then that our highest total exposures would have to be multiplied by factors of 50,000 for skin and 75,000 for inspiratory exposures in order to approach lethal animal levels. Thus, on the basis of our findings,

FIGURE 1

MALATHION EXPOSURES IN PLANADA STUDY, 1955



we can state that single applications of malathion in amounts used in these studies constitute no hazard to the normal human population.

Measures of fallout and surface deposition were made by chemical analysis of filter paper discs 32 centimeters in diameter. These discs were placed on horizontal surfaces outdoors, and inside ceilings, walls, and floors of chicken sheds and of a schoolroom within the test area. The results of these measurements are presented in Table 1.

TABLE 1. Surface deposit [1] of malathion airplane application planada study, 1955.

	Ceiling	Wall	Floor	Horizontal outdoor surfaces
Range	.09–.25	.08–.16	One Sample	1.6–9.8
Average	.14	.11	.12	4.7

[1] Micrograms per cm^2.
Source: State of California, Department of Public Health, Planada Study, 1955.

Average indoor surface deposits ranged from .11 to .14 microgram per square centimeter. These are roughly 3 percent of the average outdoor surface deposit which was 4.7 micrograms per square centimeter. Since ceiling, wall and floor surfaces each received about the same amount of deposit, we can postulate that particles which entered buildings must have been too small to follow Stokes law and thus were all below 3 microns in size. It follows then that about 97 percent of the insecticide was present in droplets too large to reach the inside surfaces of buildings. *Culex tarsalis* mosquitoes resting on these inside surfaces were thus exposed to only about 3 percent of the malathion applied. Decreasing the droplet size of insecticide so that a larger proportion is below 3 microns would appear to be the only way of increasing the exposure of mosquitoes which continue to rest inside the shelter of buildings during spray application.

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TESTS WITH AERIAL SPRAYS OF MALATHION FOR THE CONTROL OF MOSQUITOES

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The effectiveness of DDT aerial sprays for the control of adults of several species of mosquitoes has been demonstrated by Lindquist (1946), Travis (1949), Blanton (1950), and others. The widespread use of aerial sprays by both civilian and military agencies has indicated the effectiveness of both chlorinated hydrocarbon and organic phosphorus compounds against the adults of a number of species, but little information is available regarding their effect on *Culex tarsalis* Coq. Large areas were sprayed with DDT for the control of this species during the California encephalitis outbreak in 1952. However, it is doubted that these sprays were very effective, especially since this species was resistant to chlorinated hydrocarbon insecticides in 1951.

The experiments reported herein were conducted in 1955, and were concerned principally with the aerial treatment of a 2-mile-square area near Merced, Calif., with a malathion spray for the control of *tarsalis* adults. They also gave information on the effectiveness of this spray against adults of *Aedes nigromaculis* (Lud.) as well as against the larvae of this species.

APPLICATION OF THE SPRAY.—The test area consisted mostly of irrigated pastures, but also included seven sets of farm buildings and the town of Planada with a population of 1400. Prior to treatment of this area the spray was tested on adults of *nigromaculis* confined in screened cages and also on adults of the same species held in open containers under carbon dioxide anesthetization. Exposures were made in partially open buildings and also outdoors. Preliminary trials of the spray were also made on *nigromaculis* larvae in several plots.

The spray solution contained 7.5 percent of technical malathion, 4 percent of SAE 40 motor oil, 22 percent of Shell 42 solvent, and 66.5 percent of diesel oil. Application was made with three Aeronca sedan-type planes equipped with 30-foot booms. Number 4 discs were used in the nozzles, which were turned downward to a 45° angle. This arrangement produced spray particles having diameters ranging from 0.5 to 352 microns with a mass median diameter of 109 microns. The planes flew at a height of 65–70 feet, and the swath width was 60 feet. It was necessary to fly at this height because of television aerials. The planes were calibrated to deliver 3 quarts of spray, or ½ pound of malathion, per acre.

Spraying was begun at about 5:10 a.m. each day and continued for 2 hours on August 25th and for 3 hours on the 26th. The temperatures at 5:15 a.m. on the respective days were 52° and 50° F. On both mornings the wind was from west to northwest and almost at right angles to the direction of flight. The wind velocity during the spraying operations ranged from 1.1 to 2.3 miles per hour on the first day and from 2 to 5.5 miles on the second.

A 50-acre area consisting mostly of a fig orchard which extended along one side

[1] A cooperative project between the Entomology Research Branch of the U. S. Department of Agriculture, the Bureau of Vector Control of the California Department of Public Health, and the Merced County Mosquito Abatement District. The malathion was furnished by the American Cyanamid Company and the solvents by the California Mosquito Control Association, Inc. Grafton Campbell, C. A. Rischard, and Bettina Rosay of the Bureau of Vector Control assisted with the project.

of the 2-mile square was not sprayed because the oil droplets caused burning of the leaves. A 1200-foot strip was resprayed on the second day to destroy mosquitoes that might have infiltrated into it. A 15-acre orchard near the center of the plot was treated with a malathion emulsion applied with a mist blower.

The effectiveness of the spray against female mosquitoes was determined from light-trap collections and from 10-minute collections with a suction tube in several selected buildings. Five New Jersey type traps were operated in the Planada area; one was placed near the center and the others were arranged in an irregular circle around it at distances ranging from ¼ to ¾ mile, depending on the location of electric current. Collections of mosquitoes resting in buildings were made for several days before and after the spray application. As a control index three traps were placed in a similar area about 6 miles distant. This area included the town of Le Grand, which is about the same size as Planada.

DEPOSITION OF SPRAY PARTICLES.—Many spray droplets which ranged from 0.5 to 5 microns were recovered on Cascade impactor and thermal heat precipitator slides at about midpoint of the spray operations each morning. This information and information on the amount of malathion deposited on 32-cm. filter papers were obtained by Culver *et al.* (1955).

Filter papers were placed on the walls and undersides of roofs of four chicken houses where daily suction-tube collections of adult mosquitoes were being made and in four nearby locations in the open. The amounts of malathion collected on these filter papers are shown in table 1. On

TABLE 1.—Micrograms of malathion deposited per square inch in various chicken houses in Planada, Calif., test area. Data obtained by Culver *et al.* (1955).

House	Underside of roof	Wall	Flat surface in open near station
No. 13 Haskell Ave.	0.9	..	57.4
No. 14 Merced St.	1.6	0.8	59.4
No. 15 Merced St.	.6	.8	63.4
No. 16 Bigler Drive	.6	1.0	17.3[a]
Average	.9	.9	49.4

[a] High trees may account for this low figure.

filter papers placed in the open near the chicken houses and in six other locations in the test area the deposit ranged from 10.3 to 63.4 micrograms and averaged 30.27 micrograms per square inch. This is equivalent to 0.42 pound per acre, as compared with the applied dosage of 0.47 pound. The average deposit on the chicken houses was approximately 3 percent of that found on open flat surfaces.

EFFECTIVENESS AGAINST *Culex tarsalis*.—Two nights' trap collections before and two after the application showed 70 percent reduction after the treatment, or 51 percent control on the basis of Abbott's formula (table 2). A drop of 5 degrees in temperature after the spray application may have been partially responsible for the reduction. Collections made at the same time with a suction tube in 10 build-

TABLE 2.—Effectiveness of malathion sprays against female mosquitoes near Merced, Calif.

Collection	Area	Number Taken in 2 Days		Percent control
		Before spray	After spray	
		Culex tarsalis		
Traps	Test	1270	381	51
	Check	543	331	..
Buildings	Test	342	212	38
		Aedes nigromaculis		
Traps	Test	19209	643	97
	Check	3635	3252	..

ings in the Planada area showed a 38 percent control in 8 of the buildings after the spray application.

EFFECTIVENESS AGAINST *Aedes nigromaculis*.—A 97 percent control of *nigromaculis* females occurred in the Planada area, according to collections taken in the five light traps (table 2).

Three locations in the area where fourth-instar *nigromaculis* larvae were present in moderate to large numbers were checked after the spray application. All larvae in open waters were killed, but in places heavily covered with grass or where larvae were concentrated in small water holes the kill was only partial.

In the preliminary outdoor trials all *nigromaculis* adults that were anesthetized in open containers were killed by the spray, but some of those in screen cages remained alive. This was expected, since wire netting screens out some of the spray particles. None of the adults exposed in partially open buildings were killed. However, workers at the USDA Aircraft and Special Equipment Center (1954) have shown that, even if several swath widths are sprayed over a set of buildings at a height of 70 feet, the particles may drift considerably before reaching the ground. The results of our preliminary tests could therefore not be considered conclusive.

DISCUSSION.—Many variable factors, such as temperature, air movement, and humidity, may have caused differences in the numbers of mosquitoes collected on different days. However, the percentages of *tarsalis* control as indicated by light-trap and building collections were substantially in agreement, and show that malathion sprays applied by airplane for the control of the adults of this species are only partially effective. The low kill of *tarsalis* as compared with *nigromaculis* appears to be due to failure of the insecticide to reach the insect, since in laboratory tests (Gjullin 1954) malathion aerosols were only slightly less effective against *tarsalis*. The daytime resting places of *tarsalis* provide protection from sprays and are probably responsible for the low kill obtained.

SUMMARY.—An experiment on the aerial application of malathion in an oil spray at 0.47 pound per acre over a 2-mile-square area near Merced, Calif., for the control of adults of *Culex tarsalis* Coq. was conducted during August 1955. The effect on adults and larvae of *Aedes nigromaculis* (Lud.) was also observed.

Light-trap collections indicated that the insecticide caused 51 and 97 percent reduction of *tarsalis* and *nigromaculis* females, respectively. Collections made in buildings indicated a 38 percent reduction of *tarsalis* females. Complete kills of larvae of *nigromaculis* occurred in open water but not in water that was heavily covered with grass

Chemical analysis of filter papers exposed in four chicken houses showed that the papers contained 0.9 microgram of malathion per square inch, whereas those exposed in the open near the houses contained 49.4 micrograms. The average of all the papers exposed in the open, including those near the chicken houses, was 30.27 micrograms per square inch.

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PHOSPHATE USE IN CALIFORNIA MOSQUITO CONTROL

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Operational use of the organo-phosphate insecticides in California began in three mosquito districts in 1952, following developmental work by C. M. Gjullin in cooperation with the Kern Mosquito Abatement District. These materials were resorted to principally because of the increase in mosquito resistance to the chlorinated hydrocarbons, and because of the emergency situation created by the mosquito-borne encephalitis outbreak of that year.

EPN was the material applied that first year, and the principal phosphate used in 1953, when two additional districts adopted it. Some use of malathion was also made in 1953 by the Kern District in urban areas. Unfortunately, the available supply of emulsifiable EPN was exhausted that year, with the result that parathion and malathion have since been the most widely used phosphates.

It is interesting to note here that there remained an ample supply of wettable-powder EPN, but, with a few exceptions, the control agencies were not in a position to modify their equipment to handle it, and as a result switched insecticides when the manufacturers of EPN could not be persuaded to produce the emulsifiable concentrate. In view of the fact that over 120,000 pounds of malathion and parathion have since been applied for mosquito control in California alone, we cannot help but wonder if the basic producers might not find it worthwhile to reevaluate the potential market in the field of mosquito control.

In 1954, seven more districts adopted the phosphates, and four additional districts got on the band wagon during the season just completed, making a total of sixteen districts using the materials in operational quantities during 1955.

The comparisons of the extent of this use in table 1, are based upon 1954 figures compiled by Dr. W. D. Murray, of the Delta M.A.D., and 1955 data compiled by the author from a questionnaire sent to all California control agencies this winter.

TABLE 1.—Comparison of California phosphate use for mosquito control, 1954–55

	1954	1955
Agencies using phosphates	12	16
Agencies using malathion	10	12
Agencies using parathion	7	8
Agencies using both above	5	4
Agencies using EPN	2	none
Agencies making preliminary tests of malathion or parathion		3
Malathion use	20,756 lbs. 56,392 acres	51,230 lbs. 111,036 acres
Parathion use	15,454 lbs. 177,666 acres	33,716 lbs. 355,386 acres
EPN use	4,939 lbs. 50,138 acres	none
Total phosphate use	41,149 lbs. 284,196 acres	84,926 lbs. 466,422 acres

In addition to the chemicals listed, chlorthion was tested by many of the districts in 1954, or 1955, and while its results approached those of parathion and malathion, its comparatively high cost has precluded its use on an operational basis.

These materials were applied by a variety of methods, as summarized in Table 2. Virtually all of the spray applications were in the form of water emulsions, mixed from concentrates containing two or four pounds of parathion, or five or eight pounds of malathion per gallon.

Of more interest to the practicing mosquito control worker than the foregoing quantitative statistics is information about the results obtained, costs, and the techniques developed for the safe handling of these highly toxic materials.

As to results, we would not be using these insecticides if they were not highly

TABLE 2.—Methods of application of phosphate insecticides in California mosquito control during 1955

Larvicide:	Parathion	Malathion	Totals
	lbs.	lbs.	lbs.
Airplane Spray	21,598	17,850	40,489
Power spray or Mist-blower	3,953	17,159	21,112
Hand-spray	7,154	2,793	9,947
Granular, by air	20	2,410	2,430
Granular, by hand		9,067	9,067
Adulticide:			
Thermal aerosol		600	600
Air-spray	991	131	1,122
Ground spray		1,200	1,200

efficient. Of the sixteen districts which use them, thirteen report consistent 100 percent larval kills on all species with either material, one reports 95 percent results, and two, spotty results. In all three of these latter districts, malathion is the only phosphate used, but it is, of course, highly possible, in view of the excellent results in the majority of cases, that some factor other than the material is at fault here. All sixteen, including those which have made wide use of them for as long as four full seasons, report no apparent development of resistance to the phosphates in the mosquito populations.

While these materials are applied primarily as larvicides, excellent incidental kills of adult mosquitoes have been noted from the beginning. As a result, in cases where a mosquito source in an isolated area is discovered when the adults are already emerging, but before they have moved out of the area, many districts have adopted the practice of making standard larvicidal applications of phosphates, by plane or ground power spray, to kill both these adults and the remaining larvae.

With the clearance of the use of low concentrations of malathion in urban areas by the California State Department of Public Health's Bureau of Adult Health in the spring of 1955, this material began to be used more and more extensively as an adulticide, applied by thermal aerosol rigs as well as by small-particle mist-blowers. Results of this use have shown a marked improvement over materials previously used in this manner.

Costs vary from very low for parathion, to rather high for malathion. Based on prices paid by the author's district, which are believed to be consistent with those of the rest of the state, and at normal dosage rates, parathion costs about twenty-six cents per acre, while malathion runs as high as ninety-six cents per acre. Dosage rates and formulations of DDT in common use vary so widely that no general comparison with the per acre cost of this material is practical. In the author's district, where 1 lb./acre of DDT in any formulation is the smallest dose which gives reasonable kills, but where we are equipped to formulate our own 25 percent DDT concentrates at a cost of about eighty cents per gallon, DDT costs forty cents per acre. That places the cost of DDT, in our case, at almost twice the cost of parathion, and not quite half that of malathion. Of course, it cannot be emphasized too strongly that no insecticide is cheap if it does not deliver consistently good kills.

Why then, if parathion is so effective and so inexpensive, has it not been adopted as the universal insecticide for mosquito control? The answer, of course, is its extreme toxicity to warm blooded animals. This leads us to the final subject, and the one which, I am sure, is of paramount importance to those mosquito control workers who foresee a future necessity for using the phosphates, that of how these materials may be handled and applied so as to minimize the danger to humans and other animals.

Using phosphate insecticides for mosquito control may well be likened to parachute jumping. Neither are sports to be indulged in for week-end entertainment, but the pilot who is wearing a parachute when his engine quits, feels no greater relief than does the mosquito-chaser who has the phosphates to rely upon when his DDT fails him. And to carry the analogy a step further, neither parachute-jumping nor phosphate-handling are activities in

which you can learn by trial-and-error. You have to be right the first time, because your second chance may be granted only by Saint Peter. That prospect may sound rather grim, but I doubt that it would stop you from bailing out of a damaged plane, nor should it deter you from using these excellent insecticides if the need arises. Others have done both, with no ill effects, and there is no reason why you cannot as well.

The smart pilot, while he does not practice jumping, does learn to strap his chute on correctly, locates his rip-cord handle, and may even practice tumbling to learn to land without injury.

What I propose to do is tell you what we have learned in using the phosphates, about fastening those buckles, finding that rip-cord, and how to land on your feet if you do have an accident.

During the past four years, mosquito control workers in California have handled over seventy-five tons of the phosphates without a single fatality or a major injury. (The weight given is that of the actual toxic ingredients, not that of concentrates or diluted mixtures.) This has not happened by chance, but through carefully planned and rigidly enforced procedures for handling and applying these insecticides.

It should be pointed out here that these procedures vary slightly from district to district, and according to insecticide and method of application. Malathion is laboratory rated as relatively low in toxicity to mammals and is therefore used, by some agencies, with only the normal precautions afforded any insecticide. Other districts feel that, especially in the concentrated form, malathion is as hazardous as parathion, and so treat it accordingly.

Under California Bureau of Chemistry regulations, the maximum dosage allowed for mosquito control is .1 lb./acre of parathion, and .5 lb./acre of malathion. Most Districts have found that doses as low is .075 lb./acre of parathion and .3 lb./acre of malathion, give excellent results.

Since parathion is on the official list of hazardous chemicals, a permit from the County Agricultural Commissioner is required for its purchase and use. While for agricultural applications individual permits are required for each spray job, most mosquito districts receive blanket permits for periods as long as an entire season.

As has been pointed out by Dr. Radeleff, these chemicals at such dilutions are not likely to be harmful. It is, therefore, the opinion of most workers that protection of the public and of livestock, is no great difficulty, since they are normally exposed only to the diluted materials and at infrequent intervals. The only problems involved are those of maintaining constant rates of application and dilution, avoiding accidental over-dosage, and eliminating the possibility of contact with the concentrates.

The maintenance of constant dilutions and application rates is, of course, a routine problem, overcome by equipment design and operator training, which must be solved for efficient operation regardless of the material used.

Accidental over-dosages are minimized by the same means, but when they do occur, through machinery failure, etc., a routine emergency procedure of decontamination and/or quarantine of the area, as well as treatment of exposed persons or livestock must be previously explained to, and thoroughly understood by, the operator.

The final problem is solved by allowing no phosphate concentrates to be removed from a designated, protected area, or if it is necessary for refill loads to be carried on the spray trucks, requiring that these be kept in a locked, leak-proof container, and setting up loading procedures which insure against spillage of concentrates. Disposal of empty drums and cans is another phase of this problem, with procedures usually outlined by the supplier or by regulatory agencies.

The major hazard, then, is to our own personnel, who may receive daily light exposures from diluted sprays over a suffi-

cient period to cause illness, or who are exposed to the acute poisoning of small amounts of concentrates.

To minimize both types of exposure, as well as their effects, administrative planning and employee education again are the keys. Protective equipment and procedures must be provided by management, and the operators trained to use them fully. A rigid set of safety regulations is necessary, as is their strict enforcement.

Examples of equipment changes and additions which have been employed to this end are the rubber gloves, goggles, and respirators employed in repackaging concentrates into one tank-charge loads, usually in unbreakable plastic bottles, the special siphon equipment developed for mixing correct amounts of concentrate with the diluent as the latter is being pumped to the planes, the partitioned lock-boxes on spray-trucks for carrying concentrates, the soap and towels provided at each handling point and on each vehicle using phosphates, and the redesign and continuous maintenance of spraying equipment, to minimize operator exposure to drifting or leaking spray material.

Other administrative steps which should be taken are the alerting and briefing of local doctors as to the materials being used, so that they may make a special study of symptoms and treatments. Prescriptions may be obtained from them for the specific antidote, atropine, which operators may carry for emergencies. It is important that the manager, and through him the operators, receive careful instructions in when and how to use the antidote, since it is as poisonous as the phosphates themselves.

Blood cholinesterase level tests should be provided prior to first use of the chemicals and following any acute exposure or exhibition of symptoms, and may be provided on a routine monthly basis during the spraying season, which, among the phosphate-using Districts, averaged six months each year, with highs of eight months.

One of the reasons the author was requested to prepare this paper was that his district has had such tests made monthly on all exposed personnel (entomologist, four pilots, and aircraft mechanic) for the past two years, and it was felt that such a chronological picture of these enzyme levels might be of interest. However, on checking them, it was found that there was really not much to be shown, in that these levels ran steadily along through both years, with virtually no deviation from the pre-determined normals. In the two instances where pilots exhibited what might have been phosphate poisoning symptoms, extra blood tests were run, which reassured us that the cholinesterase level was normal, and, in both instances, the symptoms developed into obvious cases of virus infections. However, the fact that we have not had to use the information provided by these tests is no indication that we will discontinue them, any more than the fact that we might not have had a flat for two years would lead us to discard all our spare tires. If chronic poisoning begins to build up, we will know it in time to take steps to remedy the situation, and in cases of acute poisoning, the doctors will know the extent of the damage immediately, and therefore the amount and kind of treatment necessary.

Local veterinarians should be briefed and provided with copies of Dr. Radeleff's bulletin and other pertinent literature, so that they can recognize and treat phosphate poisoning in livestock. From the mosquito district standpoint, it is of even more importance that they be able to determine accurately when questionable cases are *not* caused by the phosphates, since this may save us the expense of purchasing beef which we are not allowed to eat.

Finally, and most important, is the education of operators and enforcement of regulations. These are the men who apply and are in contact with the materials and who will make or break the operation both from the mosquito control and the safety standpoints.

In addition to individual and class train-

ing sessions, most districts supply the operators with printed regulations, which cover, in detail, such subjects as poisoning symptoms, emergency treatments, routine cleanliness, step-by-step procedures for handling concentrates, applying sprays, cleaning and maintaining equipment, disposing of concentrate containers, etc. No attempt will be made here to cover the full information contained in these, but copies may be obtained from the Merced District, as well as, I am sure from the Kern, Delta, and Turlock Districts, among others.

One thing which the regulations employed by the various districts have in common is the concluding statement, underlined and in capital letters, which reads, *"Anyone not following these instructions will be subject to immediate discharge."* This penalty is strictly adhered to and ex-employees who have been subjected to it are considered, by all involved, to be fortunate to be unemployed but alive.

If the foregoing makes it appear that we are afraid of these materials, it is only because we are. And we will, I hope, continue to be frightened by them, because only by a constant respect for them, and vigilance in their use, will we continue alive and healthy to enjoy the real benefits which accrue from their application.

It is the author's belief that we will continue to be extremely respectful of these chemicals, and lean over backwards in taking precautions in their use, and that the full utilization of the phosphates in California mosquito control is only beginning, because they are extremely efficient mosquito killers.

Lest the impression be left that we feel that chemical control is the ultimate answer, it is necessary here at least to mention the far more important phase of mosquito control, that of source reduction through drainage and water management. To get back to our parachute, the best chute in the world is no substitute for good preventative maintenance on the airplane.

FIELD TESTS WITH TWO PHOSPHOROTHIOATES AGAINST RESISTANT SALT-MARSH MOSQUITOES [1]

JAMES B. GAHAN,[2] J. H. BERTHOLF,[3] A. N. DAVIS, JR.,[2] AND CARROLL N. SMITH [2]

As early as 1949, salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wied.) and *A. sollicitans* (Wlkr.), showed resistance to DDT in Brevard County, Fla. (Deonier *et al.*, 1950). By the summer of 1955 resistance to insecticides had developed to such a degree, in some of the intensively treated portions of Florida, that satisfactory control was not obtained with DDT, BHC, or dieldrin. The problem was so acute in Broward and Brevard Counties that other control measures were urgently needed, and field tests were made to evaluate malathion against adults and Bayer 21/199 against larvae. These compounds were selected, instead of other phosphorus compounds known to be more toxic to mosquitoes, because currently available information indicated that they are safe for the uses intended. In tests in California (Gjullin & Peters, 1956) aerial sprays of malathion at about 0.5 pound per acre had given satisfactory control of adults of

[1] This research is a continuation of investigations formerly supported directly by funds allotted by the Secretary of Defense.

[2] Entomology Research Branch, Agr. Res. Serv., U.S.D.A.

[3] Broward County Anti-Mosquito District.

Aedes nigromaculis (Ludl.) but not of *Culex tarsalis* Coq.

TESTS AGAINST ADULTS.—In October four plots in the vicinity of Dania, Fla., were treated with malathion sprays as adulticides. Plots A and B each consisted of 400 acres of marshland partially covered with low vegetation, plot C of a sparsely vegetated, 400-acre tract with a palm grove in the center, and plot D of approximately 800 acres of residential area in a town. *Aedes sollicitans* comprised at least 90 percent of the infestation in every location except the palm grove. In the shade of the palm trees most of the mosquitoes were *taeniorhynchus*.

Malathion was applied at 0.5, 0.25, or 0.1 pound per acre as a solution in No. 2 fuel oil containing 5, 5, or 1.3 percent of cyclohexanone as an auxiliary solvent. All applications were made with an N3N-3 airplane, flying at a speed of 90 miles an hour and an altitude of 75 feet. The swath width was 110 feet, and 3 quarts of spray per acre were applied to all plots. Spraying was begun as early in the morning as the pilot had adequate visibility and was discontinued before 9:45 a.m. A breeze sometimes reached 8 miles an hour while the 0.25-pound treatment was being applied, but the air was calm throughout the other spray periods.

Control was determined by comparing the number of mosquitoes per minute that landed on two men the day before and 3, 6, and 24 hours after treatment. Counts were made at 25 stations in each of plots A, B, and D. In plot C 25 counts were made in the open and 25 in the palm grove. Any reductions in the number of mosquitoes after the treatment were attributed to the insecticide. The results are shown in table 1.

Excellent control was obtained at all three dosages of malathion. After 3 hours, control was almost complete in the open marsh areas and only slightly lower in the residential area, but was substantially lower in the palm grove. After 24 hours, however, all areas showed equally good control at the lower dosages; the 0.5-pound dosage gave almost perfect control in the open. No difference was apparent between the susceptibilities of the two species of mosquitoes.

These tests, run in the fall of the year, may not be indicative of the results with the same dosages in midsummer. After the larvae reached the third instar, the weather became cool, and 8 days passed before the adults started to emerge. This retarded development may have affected their vitality and susceptibility. Further testing at temperatures more favorable for mosquito development will be required before final conclusions as to the dosages required for practical control are drawn.

LARVICIDE TESTS.—Bayer 21/199 was evaluated as a larvicide in comparison with BHC on typical salt marshes in the vicinity of Cocoa Beach, Fla. Plots A and A-1 consisted of 5 acres, B-1 and C-1 of 10 acres, and B and C of 15 acres each. *Aedes sollicitans* was the predominant species. The insecticides were applied as 16/30-mesh attapulgite granules containing 1 percent of the toxicant. All applications were made with a Stearman airplane, which was equipped with a cockpit tank duster modified to dispense granular ma-

TABLE 1.—Control of adult salt-marsh mosquitoes with aerial sprays of malathion

Plot	Terrain	Dosage (lb./acre)	Pretreatment counts [a]	Percent control after—		
				3 hours	6 hours	24 hours
A	Open marsh	0.5	581	99+	99+	99+
B	Open marsh	.25	280	99+	99+	97
C	Open marsh	.1	255	99+	99+	97
	Palm grove	.1	236	86	95	96
D	Residential area	.1	42	97	99+	97

[a] Average per man per minute.

terial. The plane was calibrated to deliver 10 pounds of granules (0.1 pound of active ingredient) per acre when a 30-foot swath was flown at 90 miles an hour. A dosage of 0.2 pound per acre was obtained by spacing the swaths 15 feet apart, and of 0.05 pound by mixing the treated granules with an equal quantity of untreated granules and flying the 30-foot swath.

Plots A and A-1 were treated during the middle of the day while a strong wind was blowing, and some of the smaller granules drifted outside the plots. Treatment of the other plots was begun very early in the morning and completed before 7:30 a.m.; throughout the period the air was calm. Control was based on 50 to 100 dipping counts before and 24 hours after application. Results of these tests appear in table 2.

TABLE 2.—Control of salt-marsh mosquito larvae with aerial applications of granules of Bayer 21/199 and BHC.

Insecticide	Plot	Dosage (lb./acre)	Pre-treatment count[a]	Percent reduction in 24 hours
Bayer 21/199	A	0.1	142	90
	B	.1	178	99+
	C	.05	620	95
BHC[b]	A-1	.1	153	0
	B-1	.1	237	41
	C-1	.2	90	0

[a] Average number of larvae per dip.
[b] Dosage of gamma isomer.

Bayer 21/199 gave high to almost complete control, whereas BHC had little or no effect. A heavy thundershower occurred between the pretreatment and post-treatment counts in plots B and B-1, increasing the quantity of water, scattering the larvae over a wider area, and reducing the number per dip in the later counts. This factor increased the control indicated in these plots and probably explains the partial control with BHC in plot B-1, as no dead larvae were found.

Summary.—Solutions of malathion in fuel oil plus cyclohexanone were applied by airplane to marsh and residential areas heavily infested with adults of *Aedes taeniorhynchus* (Wied.) and *A. sollicitans* (Wlkr.) that were highly resistant to chlorinated hydrocarbon insecticides. Treatments at 0.5, 0.25, and 0.1 pound of malathion per acre gave controls of 95 to more than 99 percent. The tests were run during the fall of the year, against mosquitoes that had developed slowly because of cool weather, and may not be indicative of the control obtainable with these dosages in the summer. Aerial applications of granules containing Bayer 21/199 at 0.05 to 0.1 pound per acre gave 90 to 99 percent control of larvae of the same species, whereas BHC at 0.1–0.2 pound of gamma was ineffective.

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SOME REMARKS ON TEXAS MOSQUITOES [1]

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The original title of this paper was "Mosquito Species Peculiar to Texas and Adjacent Areas." When I started preparing the paper, it soon became evident that the original title was much too restricted. I have consequently changed it to a more inclusive one. There are actually relatively few species of mosquitoes that are confined to Texas and adjacent areas. It is true that these few species are of considerable interest and importance, but some have been collected only a few times in the United States. Consequently, our knowledge of several of these mosquitoes is definitely limited. A few of these species will be mentioned later.

Species of plants and animals obviously pay no attention to state and national boundaries—unless these happen to be natural barriers—but because of various limitations, there has always been a tendency for workers to emphasize the species found within the state in which they live. This discussion, therefore, will emphasize those species of mosquitoes that occur in Texas.

The paper will be divided into two parts. The first part will deal with a brief comparison of the mosquito fauna of Texas with the United States as a whole and with certain other states. The second and more extensive part of the paper will consider a few species that are of interest for one reason or another.

THE TEXAS MOSQUITO FAUNA.—Texas is certainly a very strategic area for anyone interested in a study of taxonomy, speciation, evolution and related problems. This statement is true not only for mosquitoes, but also for many other species of plants and animals. There are several interrelated reasons for this situation. These include the size of the state, the location with respect to other states and countries, and the climate. These facts are more or less obvious and hardly need elaboration. Let us now see how these features, and perhaps others, affect the mosquito fauna of Texas as compared with other areas.

When one cites figures as to the number of species known from any given region, it must be emphasized that these figures are only approximations. The reasons for this include the question of species versus subspecies, and the possibility of an occasional incorrect determination.

There are at present approximately 137 species of mosquitoes known from the United States. These figures, incidentally, apply only to the group that is sometimes called the true mosquitoes. By some systems of classification, this is the subfamily Culicinae. The subfamilies Chaoborinae and Dixinae, which are often combined with the Culicinae to make up the family Culicidae, are not considered in the present discussion.

Only one genus of mosquito known from the United States is not represented in Texas. This is the genus *Wyeomyia* Theobald, species of which breed in the water in pitcher plants and similar situations. Of the 137 species recorded from the United States, 73 have been reported from Texas.[3] The number of species of mosquitoes known from certain other states in various parts of the country might be of some interest. These include California, 66, Florida and the Florida Keys,

[1] Some of the work mentioned herein was done while working on projects supported by research grants, E-507, E-507(C) and E-507(C2), from the Microbiological Institute of the National Institutes of Health, Public Health Service, and the University of Texas Research Institute.

[2] The writer wishes to thank Mr. James D. Long who helped in the compilation of data presented in this paper.

[3] Since this paper was written, an additional species, *Culex erythrothorax* Dyar, has been reported from Texas: Mosquito News 15:235.

64, Oklahoma, 52, Illinois, 52, and New York, 52. Texas, then, has more, and perhaps better mosquitoes than any other state.

Some Interesting Species That Occur in Texas.—The remainder of the paper will be devoted to a few species of mosquitoes that are of some interest, either because of their limited distribution in the United States, or because of certain problems associated with them. The first group to be mentioned are those that occur in Texas, but which have a limited distribution in the United States.

Culex abominator D. and K.: This mosquito is known only from Texas, but it is the only species having this distinction; other species in the state have also been collected elsewhere. This species has been collected primarily from the central and eastern part of the state. As yet, little is known of its biology.

Culex virgultus Theo.: This species has been known as *C. declarator* D. and K., but Lane (1951) considers that the two are the same. *C. virgultus* Theo. as the older name, therefore, has priority. The mosquito occurs in Mexico, Central American and adjacent areas, but has been reported only from Texas in the United States. It has been collected primarily along the Texas-Mexico border, and has been considered rare. However, we recently collected large numbers of this species which indicates that it is not so rare as formerly thought (Breland 1954). Relatively little is known of the biology of this species.

Culex interrogator D. and K.: *Culex interrogator,* so far as known, is limited in its distribution in the United States to the southeastern Rio Grande valley area of Texas. The larvae have been collected in water with a relatively high organic content such as rain barrels, tree holes and ruts. They have also been collected in seepage areas from irrigation ditches (Thurman, Ogden and Eyles, 1945).

Aedes bimaculatus (Coq.): This species has been collected in the United States mostly in the southeastern Rio Grande Valley area of Texas. We have collected a few larvae, tentatively determined as this species, nearer the central part of the state. In the absence of adults for more positive confirmation, however, we prefer to regard this as a tentative report for the present.

Deinocerites spanius (D. and K.): This species was first reported from the United States in 1941 (Fisk, 1941) with the collection of both larvae and adults near Brownsville, Texas. It is apparently confined to the southeastern tip of the state.

A few other species of mosquitoes should be mentioned briefly with respect to their distribution in Texas and the United States.

Deinocerites epitedeus Knab was reported by Rueger and Druce (1950) on the basis of a single specimen from a light trap collection near Harlingen, Texas. This specimen is regarded by Carpenter and LaCasse (1955) as an intrusion from Central America, or as a misidentification. Several females of *Psorophora mexicana* (Bellardi) were collected by Joyce (1945) near Brownsville, Texas. So far as could be determined, this is the only time this species has been collected in the United States. Some workers believe that the species was accidentally introduced into Texas by ship or airplane (Carpenter and LaCasse, 1955), and that it probably is not well established in this country.

Anopheles albimanus Weid. and *Aedes scapularis* Rondani have been collected in the United States only from Texas and Florida. *Culex coronator* Dyar and Knab was known only from Texas in the United States for many years but it has been recently reported from Arizona (Murphy, 1953).

Until 1948 it was assumed that the subgenus *Neoculex* was represented in the United States by a single species, *Culex apicalis* Adams. Bohart (1948) found that four species were involved in this complex in the United States; *Culex apicalis* as limited in this publication was recorded only from California and Arizona in the United States. We collected larvae of this species from the Big Bend National Park in west Texas in 1953, and in the vicinity

of Alpine and Fort Davis in 1954. Adults were reared so that larval and adult features could be correlated. So far as we know, this is the first time this species has been collected from the state.

The other species to be discussed briefly are mentioned because of certain interesting features other than their distribution.

Orthopodomyia alba Baker: This mosquito is of interest for at least two reasons. First, until a short time ago it was considered to be a rare species, and secondly, even today there is no known feature by which the adults of *O. alba* can always be distinguished from those of *O. signifera* (Coq.).

O. alba is still regarded as being rare in many areas, but we have collected hundreds of larvae from several localities in central Texas. In this area it is not especially rare, but it has been recovered from only a small percentage of the tree holes that have been investigated.

We have studied hundreds of larvae of both species from this area, and have never found one that is intermediate between the two. This situation indicates to us that the two groups do not interbreed, even though the adults are indistinguishable, and even though the two are often collected from the same tree hole. We thus believe that the two are genetically distinct, and that they should retain full specific rank (Wilkins and Breland, 1951).

We regret to say that as yet we have not completed our project of rearing and studying large series of adults of both groups. The student to whom this problem was assigned was called into the armed forces before he could complete the work. We hope that he will be able to return shortly and finish this work.

Culex stigmatosoma Dyar and *Culex thriambus* Dyar: For many years, *C. thriambus* was considered as a synonym and as a subspecies of *C. stigmatosoma.* Galindo and Kelly (1943), however, in studying California specimens, restored *C. thriambus* to full specific rank. Some time ago we undertook a study of these two mosquitoes, since there was still some confusion as to the status of the two groups as found in Texas.

Our studies of these two groups are still incomplete, but there are several things relative to the two that we would like to mention at this time. We have examined hundreds of larvae of the two species and have not found any intergrades. Neither have we found any indications of interbreeding in our studies of the adult females and the male terminalia. So far, however, we have not studied a sufficient number of adults to be sure that the differences we have found will hold for large series. Our present opinion is that the two are separate and distinct in Texas as has been found to be true in certain other areas.

Until our studies of these species had been made, there was some indication that the ranges of *C. thriambus* and *C. stigmatosoma* did not overlap in Texas. On the basis of some collections, *C. stigmatosoma* appeared to be limited to the western tip of the state, and *C. thriambus* more or less confined to the central region. Our collections have not especially changed the known distribution of *C. stigmatosoma,* but that of *C. thriambus* has been considerably modified. We have collected this species in the Big Bend National Park in Brewster County, and on two occasions, near Fort Davis in Jeff Davis County, larvae of *C. thriambus* and *C. stigmatosoma* have been collected from the same body of water. These collections show that *C. thriambus* does occur in west Texas and that its range overlaps that of *C. stigmatosoma.*

In conclusion, one additional point relative to the larvae of *C. stigmatosoma* should be mentioned. Although we have not found any intergradation between the larvae of this species and that of *C. thriambus,* we have found that, in key characters, the larvae of *C. stigmatosoma* vary tremendously. This variation was noted especially in the number and arrangement of the hair tufts of the siphon. If one checks the publications in which the larvae of *C. stigmatosoma* are described, it

will be seen that there is considerable disagreement so far as these particular features are concerned. We have only studied large series of larvae that were collected in Texas, but it is suggested that the tremendous variation of the larvae is the reason for the disagreement in the literature.

The variations noted above are such that they might not be noticed if only a few larvae are examined. The results of the studies of larval variations will be published shortly.

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TEXAS METHODS OF ORGANIZING AND FINANCING MOSQUITO CONTROL WORK

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Industrial progress has brought expanding population to a point where all sections of Texas are growing faster each year, and we have outgrown the laws that guided our progress in early days. Today we find cities extending far into our rural areas. We find modern homes in last year's cotton patch. Where we formerly had one rustic outhouse to take care of the needs of the family today we find modern homes with two or three bathrooms. Where we used to have one car in every driveway we now find two or three.

With this consuming desire for independence, privacy and a fair share of the "wide open spaces," we are moving to the rural areas of yesterday. Convenient large community centers are being built. Office workers and others have their homes in the country and drive over express highways each day into the business section where their living is made. At night they return to enjoy the luxury of their modern, rural homes.

This change in our way of life has brought about problems in those areas extending from our city limits to our county lines.

Cities have the authority to pass ordinances to keep pace with their growth. Ordinances requiring certain spacing between homes, the width of streets, etc., are for the protection of the person where he lives and for the protection of the general public.

Commissioners' Courts, on the other hand, have only that authority given them by our Legislature. The Constitution in creating the Commissioners' Court did not clothe it with any general authority over county business, but merely gave it such special powers and jurisdiction as is conferred by the Constitution itself and the laws of the State as might be thereafter prescribed.

Decisions of the Texas courts have repeatedly held that a Commissioners' Court is a court of limited jurisdiction and has only such powers as is conferred upon it either by specific terms or by the statutes and Constitution of this State.

The two authorities that we have today controlling those areas outside of our cities are (1) that authority contained in Article 974a of our Texas Civil Statutes which gives cities the right to regulate their future growth within an area of a five-mile radius. This law provides that the city planning commission (or the governing body where there is no planning board) may require that plans of all subdivisions within a five-mile radius of the city be approved before permitting them to be recorded by the County Clerk.

The second authority is the right of cities to require the same regulations to be met by those that are furnished water by the city, outside of the limits, as those that receive water within the city limits.

These two are the only authority that we have to take care of that area extending from city lines to county lines and which is referred to as "No Man's Land."

This area lacks any control measures by the city or the Commissioners' Court. Here the dumping of garbage and waste cannot be controlled. There is no proper garbage collection. Abandoned water wells are used for cesspools. Cattle feeding lots are permitted to exist. Wastes from the cattle become breeding places for flies and the stench and odor are carried into town. Taverns, dance halls, and small carnival grounds operate without any thought of proper sanitation. Substandard housing units are built. Industrial plants operate without any authority or planning of their structure or management. Mosquito breeding in salt marshes or low areas of stagnant water is permitted to exist and

the mosquitoes are carried by the breeze into neighboring cities. These are but a few of the many complaints we receive in the Health Department from all parts of Texas. The nearby cities are helpless to control such hazards to health. The Commissioners' Court lacks proper control. All of these conditions not only menace health but at the same time are factors which lower property values.

Because Commissioners' Courts lack the authority to control specific health problems or nuisances in that area extending from the city limits to the county line, authority had to be obtained from the Legislature to set up Mosquito Control Districts.

Since mosquitoes were endangering the health of the citizens of this State, especially in those areas bordering on the Gulf of Mexico, the 51st Legislature at its Regular Session in 1949 provided for the creation, regulation and financing of Mosquito Control Districts "in all counties of this state which border on the Gulf of Mexico. . . ." This Act authorized the Commissioners' Court in such counties to call an election upon being petitioned by two hundred (200) qualified voters; the form of the ballot for the establishment of a Mosquito Control District was prescribed by the Act and also an authorization for a levy of a tax not to exceed five cents (5¢) on each one hundred dollar ($100) tax valuation to obtain funds to finance the program.

The Act further authorizes the appointment of an Advisory Commission for the Mosquito Control District composed of five (5) members who shall be qualified property tax paying voters of the county. "Each commissioner of the Commissioners' Court and the County Judge shall appoint one (1) member of the Advisory Commission. Members of the Commission would serve without compensation."

The Commissioners' Court was further authorized to appoint a Mosquito Control Engineer "well qualified in the field of mosquito control who shall serve at a salary which shall be determined by the Commissioners' Court and he shall be under the supervision of the Commissioners' Court."

This law was amended by the 54th Legislature so that now a Mosquito Control District may be composed of two (2) or more counties. The amendment to the Law which adds a new section number 6A reads as follows:

"The Commissioners' Court of any two or more counties operating under the provisions of this Act may enter into an agreement for the merging of their separate districts into a single mosquito control district composed of such two or more counties. Said Commissioners' Court shall enter into an agreement that in all respects complies with the provisions of this Act, except that the advisory commission and mosquito control engineer, as required above, may be appointed for the entire district, rather than for each county."

This amendment became effective April 29, 1955.

Our General Sanitation Law, Section 1, subsection (g), defines a nuisance in the following language:

"Any object, place or condition which constitutes a possible and probable medium of transmission of disease to or between human beings or any other object, place or condition which may be specifically declared by this Act to be a nuisance."

In the same Law, Section 2, subsection (a), reads as follows:

"Any and all of the following conditions are hereby specifically declared to be nuisances dangerous to the public health;"

In subsection (h) the following condition is specifically declared to be a nuisance:

"Any collection of water in which mosquitoes are breeding within the limits of any city, town or village;"

In a broad sense, a nuisance is anything that works injury, harm or prejudice to an individual or the public. (20 R.C.L., p. 380, sec. 1.) A nuisance has also been defined as anything that "obstructs, impairs, or destroys the reasonable, peaceful, and comfortable use of property." (True-

heart v. Parker, Tex. Civ. App., 257 S.W. 640, 641.)

Acts which are denounced as illegal by law, when the perpetration of them invades the rights of others will be nuisances *per se*.

The term "nuisance" means literally "annoyance,"—anything that works hurt, inconvenience, or damage. (Miller v. Burch, 32 Tex. 208, 5 Am. Rep. 242.)

A nuisance is anything that works an injury, harm, or prejudice to an individual or the public, and will embrace everything that endangers life or health, offends the human senses, transgresses laws of decency, or obstructs, impairs, or destroys the reasonable, peaceful, and comfortable use of property. (Trueheart v. Parker, 257 S.W. 640.)

Every citizen has the right to the enjoyment of his property without hurt or injury from any unlawful acts or conduct of his neighbor. (Fields Sewerage Co. v. Bishop, 30 S.W. 2d 412, error refused.)

In a more recent case, Newton v. Town of Highland Park, 282 S.W. 2d 266, a swimming pool which was found to have been a breeding place of mosquitoes could be required to be corrected, even though jury found that such fact did not endanger health of citizens.

Any place that is found to be a breeding place of mosquitoes should be corrected. Under our Texas law it is defined to be a nuisance. Under our court decisions it does not necessarily have to be a health hazard. Unfortunately, though, at the present time our authority to create Mosquito Control Districts is limited to those counties in this State which border on the Gulf of Mexico.

The law authorizing the formation of Mosquito Control Districts has served a valuable purpose and has given relief and improved living conditions in those counties of Texas bordering on the Gulf of Mexico where mosquitoes have been a problem for many years. We in the State Health Department who have assisted in this program feel that such a program should be available to any county in Texas where mosquitoes create a problem. At the present time this is impossible. We believe that an amendment should be made to our present law so that such a program would not be limited to the coastal areas of Texas but would be available to any county where the formation of a Mosquito Control District is needed.

The present financial structure limiting an authorization for a levy of taxes not to exceed five cents (5¢) on each one hundred dollar ($100) tax valuation should be amended and a tax levy of at least twenty-five cents (25¢) on each one hundred dollar ($100) tax valuation or a limit of this amount should be authorized. Such an amendment would enable less fortunate counties not blessed with industrialization and valuable real properties to collect sufficient funds to support adequate mosquito control programs.

The increasing trend of our population toward rural areas where tremendous investments are being made in housing, makes it a matter of critical importance that our statutes be amended to more adequately control mosquito breeding in these areas as well as other nuisances and problems related to public health. The matter of mosquito control can be accomplished only when any county has the authority to initiate an over-all control program and collect an adequate tax to cover the cost of the program.

ROLE OF THE TEXAS STATE DEPARTMENT OF HEALTH IN MOSQUITO CONTROL

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Two major divisions of the State Department of Health are concerned with mosquito control, the Division of Sanitary Engineering and the Division of Laboratories. The Division of Sanitary Engineering is concerned with promotion, operations and research and has a Vector Control Section included under General Sanitation Services. The Division of Laboratories includes an Entomology Section and provides general laboratory services. Both divisions collaborate on matters of mutual concern, including research.

In times past the State Department of Health has been primarily concerned with such common mosquito transmitted diseases as malaria, yellow fever, dengue and, more recently, infectious encephalitis. Organized efforts toward the control of malaria in Texas commenced with education, screening of homes, drainage, conditioning of residual water and larviciding during and immediately following World War I. These activities continued progressively through the years with State and Federal funds until the period immediately following World War II, when a joint State and Federal approach to the problem actually brought about the near eradication of this once dreaded scourge. A few questionable cases of local origin are still reported annually by a few isolated physicians; however, almost invariably, laboratory confirmation is unobtainable. The vectors of malaria are still prevalent in a wide area of the State, however, necessitating a surveillance program. A further complicating factor is presented by the large numbers of Mexican Nationals from malarious regions of Mexico that are imported to harvest crops.

Yellow fever, although still accounting for numerous fatalities in the very early 1900's, had virtually disappeared from the State by the time the State Department of Health was sufficiently well organized to formulate a specific program. Sporadic outbreaks of dengue have occurred; however, these outbreaks have been promptly attacked through a combination of education, environmental sanitation and chemical control. Although a few isolated foci of *Aedes aegypti* mosquitoes still are present in the State, epidemics have been unknown during the past 15 years. The known vectors of infectious encephalitis occur in virtually all sections of the State, and occasional clinical as well as near epidemics are recognized.

In keeping with modern concepts the thinking has gradually come around to recognizing a comfortable environment as a major part of the public health program. This includes the control of socalled pest mosquitoes insofar as appreciable numbers affecting significant portions of the human population are concerned.

Since the State is currently limited insofar as actual financial participation in operating programs is concerned, efforts are largely confined to promotional work and technical services within budgetary limitations.

A few of the functions performed by the State Department of Health include the following:

1. Preparation and distribution of technical information, bulletins and other training aids.
2. Conducting training seminars and refresher courses for technical representatives of local political subdivisions.
3. Provision of technical consultationship to operating programs.
4. Identification of mosquitoes and general laboratory services.
5. Mosquito surveys with technical reports and recommendations.

6. Provision of emergency technical aid to communities affected by disasters and epidemics.

7. Review of plans and technical recommendations for the prevention of mosquito propagation in the construction of drainage, flood control and major water impoundment projects.

8. The review of operational and mosquito collection reports.

9. Public relations activities in encouraging the activation of mosquito control programs.

Among the many mosquito problems confronting the State of Texas are the many miles of coastline with the inevitable salt marsh acreage that is subject to periodic inundation from the coastal tides. This normally creates a bad salt marsh mosquito problem; moreover, occasional high tides bring about the flooding of abnormal acreage and the consequent emergence of astronomical numbers of salt marsh mosquitoes. Usually the control programs in adjacent municipalities are poorly equipped to function adequately under these exceptional conditions, and there is considerable distress and suffering among the affected population.

Commencing with Jefferson County in 1949, six counties have voted in county-wide mosquito abatement districts under the existing enabling legislation. This legislation is restrictive to the coastal counties touching the Gulf of Mexico and is otherwise in need of revision. This current legislation is inadequate to permit a realistic approach commensurate with the problem. More adequate state legislation in the form of a constitutional amendment will be necessary before the Texas Gulf Coast, as well as the interior counties, can hope to provide the population with the type of comfortable environment that is currently in demand.

Since health agencies have largely been the ones concerned with mosquito control during past years, and budgetary restrictions on research have of necessity been confined to mosquito vectors rather than pest mosquitoes, considerable technical knowledge is lacking concerning the most suitable techniques for salt marsh mosquito control. Operating mosquito abatement districts have a public obligation to use available funds to provide the maximum relief for the affected public and seldom can afford to devote extensive time and energy for extensive research. Fortunately, badly needed federal legislation has now been introduced in both the House and Senate and makes provision for both field research and demonstration type programs concerning all significant mosquitoes in the various coastal and other environments.

MOSQUITO CONTROL WORK IN LOUISIANA

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Since the eradication of malaria as a disease of public health importance in Louisiana, the function of the State Health Department, so far as insect control work is concerned, has been entirely promotional and advisory. Three members of the staff of the Section of Insect Vector Control travel the State almost continuously, consulting with municipal officials and local health department personnel regarding insect problems. Local programs are organized in the winter and early spring. In the case of a community which has not previously carried on a mosquito control program, a survey is made and the local officials advised of what will be needed in the way of personnel and materials. Later, when it is time to begin work, another visit is made and the local personnel instructed in the methods to be used. Follow up visits to evaluate and advise are made at intervals throughout the breeding season.

In 1955, 92 communities with a total population of 803,000 carried on successful mosquito control programs.

Fifty-one species of mosquitoes are found in Louisiana. Some of these are quite common, while a few are very rare. Distribution and density records are broken down into four general classifications according to the numbers and range of the various species. A species is placed in group Number 1 when it is abundant and widespread over a long season. A species abundant only over a short season or found only in certain parts of the State is classified as Number 2. The Number 3 species are widespread but are found only in small numbers. Those in the Number 4 group are rarely found.

There are 21 species in Louisiana in the Number 1 group. These are as follows: *Anopheles crucians, A. punctipennis, A. quadrimaculatus, Aedes aegypti, A. atlanticus, A. infirmatus, A. triseriatus, A. vexans, Culex apicalis, C. erraticus, C. quinquefasciatus, C. restuans, C. salinarius, Psorophora ciliata, P. confinnis, P. cyanescens, P. discolor, P. ferox, Culiseta inornata, Uranotaenia lowii, Uranotaenia sapphirina.*

Fifteen fall in the Number 2 group and 15 in the Number 4 group. There are none in the Number 3 group.

As examples of the 15 species in group 2, *Aedes canadensis, Culex peccator,* and *Anopheles barberi* might be named.

Examples of the species in group 4 are *Anopheles atropos, Aedes tormentor* and *Orthopodomyia alba. O. alba* has been found in only one parish in the State.

The vectors of yellow fever, dengue and malaria (*Aedes aegypti* and *Anopheles quadrimaculatus*) have ratings of 1, which would make them extremely important from the public health view point if there were yellow fever or if malaria were indigenous in the State. In the absence of these diseases, the Health Department is more concerned, because of public pressure, with the so-called pest mosquitoes.

Of the nuisance mosquitoes, the nine species of *Psorophora* are by far the most troublesome in the northern part of the State, while *Aedes sollicitans,* the salt marsh mosquito, is of the greatest importance in the coastal region. There is occasional trouble with *sollicitans* in the oil-producing areas remote from the coastal marshes when salt water is pumped from the oil wells. *Culex quinquefasciatus* is troublesome throughout the State.

The *Psorophora* mosquitoes have been controlled to a certain degree, where they are most prevalent, through the use of fog and mist machines. Little or no success has been met with in attempts to cope with the *sollicitans* problem, which is apparently increasing in severity from year to year. Some idea of the magnitude of this problem may be grasped from knowl-

edge of the fact that of the approximately 5,600,000 acres of salt marshes in the South Atlantic and Gulf Coast states, from Virginia to Texas, more than half of them, or 3,381,500 acres, are located in Louisiana.

In 1955, the first *sollicitans* invasion of the year occurred on April 15, a date considerably earlier than that of the first invasion of previous years.

It was notable that following an inch or so of rain which ended on February 25, there was no further rainfall until April 8–13, in which period about six inches of rain fell. The weather had not been particularly cool. There seems to be little doubt that the very severe invasion was a result of the long, dry, comparatively warm spell followed by the heavy rains.

There was no rain from April 13 until May 15 when 6 inches of rain fell in a period of two days. On about May 22 the second severe invasion occurred. Again there was little rain until near the end of June when the almost daily seasonal rains began which brought the third and last invasion of the year. Fortunately, the breeding habits of this species are such that frequent rains tend to reduce the rate of propagation.

So far, Louisiana has been able to do very little but talk about this problem. Those most familiar with it are convinced that a solution is impossible with the resources now available. It is a situation which seems to cry for study and research.

GRANULAR PESTICIDES IN CALIFORNIA MOSQUITO CONTROL

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The use of granular pesticides has become more or less a routine method of larval mosquito control in many of the mosquito abatement agencies of California. Other agencies have, from time to time, experimented with their use and in many cases have found the granulars to be extremely effective for specialized situations in mosquito control. The use of pelleted or granulated insecticides for mosquito control purposes is not an entirely new development. Dr. F. E. Whitehead (1) reported in 1950 at the Chicago meeting of this association on the use of pellet-borne insecticides for rice field mosquito control. Others have reported use of these materials in subsequent years (2), (3),(4).

Basically the carriers for the toxicants have been bentonite and diatomaceous earth. Bentonite has, in most cases, apparently been the most satisfactory material. No use of vegetable carriers such as spent tobacco stems has been used in the west, principally due to their scarcity. In fact great difficulty has been experienced by some of the chemical companies in California in obtaining adequate supplies of the carrier materials at prices within the scope of mosquito control budgets. This past season (1955) has seen a marked improvement in this matter. In previous years granulars have been supplied from 15–60 mesh size with the 15–20 mesh appearing to be the best for mosquito control. Uniformity of particle size has been a problem as has the dust from the finest portions of any particular material. These problems are being solved rapidly as granulars are being developed for other purposes, notably fertilizer combinations.

At first (1951) only toxaphene was available as a granular. As the use and testing has advanced, more and more toxicants

have become available. Some of these have been DDT, DDT-dieldrin, dieldrin, heptachlor, malathion and parathion. There must be, in time, a decision made as to which toxicant will, in all cases, give the desired kill. This is necessary for reasons of economy. As mosquito resistance to the chlorinated hydrocarbons has advanced in California a shift to the phosphate insecticide toxicants has occurred. In the 1955 season by far the greater majority of granulars used by mosquito abatement agencies were either malathion or parathion.

Actual experience with the granulars for mosquito control in California has been varied. Results have not always been consistent. In general it can be stated that where sufficient amounts of toxicants have been applied results have been satisfactory. Some agencies still expect granulars to kill mosquito larvae at dosage rates far less than usually applied by other larviciding methods. Good results can not be expected under these circumstances.

The number of mosquito abatement agencies which employed the use of granulars during this past season (1955) was considerably less than in former years. Why this is so is not known. The fact that the 1955 season was comparatively light in mosquito problems in California may have contributed to this situation. Also in the past many districts had used the granular pesticides only experimentally, often with poor results. Nevertheless, the agencies which used these pesticides on a regular control basis had satisfactory results. A total of eight mosquito control agencies in California reported the use of granulars for 1955. About 25,000 pounds of granulars were used by these agencies in their control programs. Below is listed certain information as reported by these districts.

From the results reported it can be seen that, in general, satisfactory kill of mosquito larvae was obtained. As stated previously, use of the granulars has been somewhat restricted to special situations. Only two agencies consistently use granulars in their control programs. Continued use of them will be made by these agencies for they find these materials well suited for their particular jobs.

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GRANULAR PESTICIDE RESULTS—1955

District	*Material*	*Method*	*Dosage per acre*	*Species*	*Control*
Turlock MAD	Malathion	hand	0.5 lb.	*Aedes nigromaculis* + *culex tarsalis*	good
Sacramento-Yolo MAD	Malathion	hand	0.5	same	poor
San Joaquin MAD	Malathion	air	0.35	same	good
Kern MAD	Malathion	hand & air	0.5	same	good
Madera Co. MAD	Malathion	air	0.5	same	good
Tulare MAD	Parathion	air	0.1	*C. tarsalis*	poor
Butte Co. MAD	Toxaphene	air	0.6	*C. tarsalis*	fair
Sutter-Yuba	Dieldrin	air	0.1	*C. tarsalis*	poor

DISPERSAL OF MOSQUITOES THROUGH TRANSPORTATION, WITH PARTICULAR REFERENCE TO IMMATURE STAGES

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The accidental dispersal of insects through various modes of transportation has always posed a threat to the welfare of man and has often resulted in serious hardship to him. Such dispersal made it possible for many species to become established along various trade routes of the world.

Although numerous insects have been transported in the adult stage, it has not been unusual for them to be dispersed in the larval or other immature stage of their life history. It is with the latter phase of dispersal that this paper is primarily concerned. Accordingly, the writers have cited a few examples showing how mosquitoes have been dispersed, often in their larval stage, and sometimes have become established in areas new to the species. An interesting early discussion on the subject of dispersal of mosquitoes by various types of conveyances is given by Howard *et al.* (1912).

MOSQUITO ESTABLISHMENT FOLLOWING DISPERSAL BY SHIP: ESTABLISHMENT OF MOSQUITOES DURING EARLY DAYS. Although there were undoubtedly many species of mosquitoes established along world shipping routes during the nineteenth century or earlier, a few examples will suffice in pointing out such implantations.

In writing on mosquitoes of Australia, Skuse (1889) described a species of *Culex* which he did not name but which, from the description given, might well have been *Culex quinquefasciatus* Say. He indicated that this mosquito may have been introduced into Australia from Europe on old sailing vessels where it could have bred in water tanks. He suggested that the same species had been widely dispersed in Australia by means of railroads and that it was then being further communicated to other places on the coast by water traffic.

Mosquitoes were unknown to the Hawaiian Islands until the late eighteenth or early nineteenth century, when they were brought there by sailing vessels on which they undoubtedly were breeding. According to Osten-Sacken (1884) mosquitoes most likely were introduced into Hawaii about 1828 to 1830. He suggested that larvae of *Culex* probably were imported in water tanks on an old sailing vessel from Mexico which was abandoned on the coast of one of the "Sandwich Islands" during that period. Van Dine (1904), in writing on the introduction of mosquitoes into Hawaii, indicated that they were introduced into the Island of Maui in 1826 on the ship "Wellington," which came from Mexico. According to Van Dine's report the first species of mosquito introduced into the Hawaiian Islands presumably was *C. quinquefasciatus,* while *Aedes aegypti* (Linn.) and *Aedes albopictus* Skuse arrived somewhat later. Kirkaldy (1907), mentioned a reference which attributed to one of the Islands' older historians a statement to the effect that mosquitoes were not known there until the arrival of Captain Cook's ships, implying that they were brought in about 1778 or 1779.

Although there may be some controversy as to the actual date of introduction, it is rather well established that three species, *Culex quinquefasciatus, Aedes aegypti,* and *Ae. albopictus,* were brought to the Hawaiian Islands by sailing vessels. These species apparently have remained the only mosquitoes which have become established in the Islands by accident. Although the three species are present there today, it is the writers' understanding that the num-

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ber of *Ae. aegypti* is being reduced gradually.

In addition to the three species of mosquitoes mentioned for Hawaii, attempts were made in 1929 by Pemberton (Williams, 1931) to establish the carnivorous *Toxorhynchites* (*-Megarhinus*) *inornatus* (Walker), and in 1950 by Bonnet and Hu (1951) to establish *Toxorhynchites brevipalpis* Theobald. It was hoped by the workers mentioned that the carnivorous larvae of these non-biting mosquitoes would assist materially in the control of *Ae. albopictus* by attacking its immature stages.

Establishment of Mosquitoes in the Central Pacific Area. Throughout the years mosquitoes have continued to gain a foothold in areas new to the species involved. Such was the case in some of the Central Pacific Islands during the World War II period.

Anopheles subpictus indefinitus Ludlow, a species indigenous to the Philippines, was found established on Guam in 1948, according to Yamaguti and LaCasse (1950), Reeves and Rudnick (1951), and Reeves (1953). This appears to have been the only time an anopheline mosquito has become established in the Central Pacific-Micronesian area. The same workers, in addition to reporting on *An. subpictus indefinitus,* also reported the finding of *Ae. albopictus* on Guam in 1948, in what was presumed to have been the first record of this species for Guam. However, Hull (1952) mentioned that larvae of *Ae. albopictus* actually were found on the island as early as 1944.

Although it is not known how or in what stage of their life history *An. subpictus indefinitus* and *Ae. albopictus* gained entrance to Guam, Reeves (1953) indicated that they may have entered by means of surface craft during military operations.

Ae. aegypti and *C. quinquefasciatus* were found on Wake Island in a survey of 1947 and 1948; however, according to Reeves (1953), apparently there were no mosquitoes on the island as late as December 1941. Their mode of entry to Wake, whether by aircraft or surface vessel, is unknown.

Reeves (1953) also reported that he collected *C. quinquefasciatus* on Kwajelein Atoll from which it had not been reported.

There are additional records of permanent or temporary establishment of mosquitoes in other Pacific islands during the World War II period which need not be cited here.

Early Transportation of *Aedes aegypti* and Other Mosquitoes by Ships. The Public Health Service in its broad health programs has been actively interested over the years in the accidental transportation of arthropod vectors of diseases such as plague, typhus, and yellow fever. Some specific examples, recorded by various workers approximately 50 years ago will be mentioned.

At the beginning of the present century, soon after *Ae. aegypti* was proved beyond doubt to be the vector of yellow fever, a number of Public Health Service workers conducted studies on the transportation of *Ae. aegypti* to United States ports. Interest in this work was given impetus by the presence of yellow fever in a number of countries to the south and, from time to time, in our own country. The last epidemic of yellow fever to occur in the United States was in 1905. At that time it was confined almost entirely to Louisiana (Surgeon General, 1907), and resulted in 8,399 cases with 908 deaths.

In 1901 Cumming (1901), a Public Health Service medical officer, who later became Surgeon General of the Public Health Service, reported the presence of what he termed a "perfect plague" of mosquitoes on board the Spanish bark Maria Blanquer which arrived at a quarantine station in the South from Rio de Janeiro. Although the master was positive that there were no mosquitoes on board until the twenty-second day at sea, when they were observed in a water tank which was opened, they were so abundant upon arrival that, following fumigation, they could be gathered up by the handfuls.

In 1902 Grubbs (1903), a Public Health Service medical officer at a southern quarantine station, conducted studies to determine to what extent yellow fever mosquitoes were being carried by ships arriving at that station. During the summer of 1902 observations were made on 82 ships (78 sailing vessels and 4 steamers) which arrived from ports where *Ae. aegypti* was present. In addition to on-arrival inspection, consideration was also given to the presence of mosquitoes on these ships prior to departure for the United States and while en route. Of the ships observed, 17 had mosquitoes on board at some time during the voyage, but only three arrived with *Ae. aegypti* present. Of these three vessels, only one had larvae of *Ae. aegypti* present on arrival, although adults of this species were observed on all three throughout the voyage. Undoubtedly, mosquito breeding occurred on all three vessels during their voyages to the United States from Vera Cruz, Mexico, which required 13 or more days for each ship.

Parker *et al.* (1903), in commenting on the transportation of mosquitoes by ships at the beginning of the present century, stated that thousands of larvae of *Ae. aegypti* were found in wooden tanks and in other fresh-water containers on the American schooner John H. Crandon sometime following its arrival in Mexico from a southern United States port. This ship, which was examined at the Mexican port where a case of yellow fever occurred among the crew, subsequently departed, still heavily infested with mosquitoes. Grubbs (1903) reported that it arrived at a United States port with many mosquito larvae and adults on board.

The foregoing will suffice to indicate that mosquito breeding was common on ships early in the century.

RECENT RECORDS OF MOSQUITO BREEDING ON SHIPS AND AIRCRAFT: MOSQUITO BREEDING IN SHIPMENTS OF OLD TIRES. There have been several instances in which mosquito breeding has occurred in old tires which were being shipped to the United States or elsewhere. The most outstanding example of mosquito breeding in tires transported to the United States was reported by Pratt *et al.* (1946). During 1945 and early 1946, 12 ships which arrived at Los Angeles, California, contained cargoes comprising thousands of old tires and other salvaged equipment from combat areas of the Pacific. Routine examination of these ships by Public Health Service quarantine personnel revealed the presence of fresh water in numerous tires in 8 of the 12 ships involved. The quantity of water per tire varied from a very small amount to as much as five gallons. The water presumably gained entrance to the tires, as well as to other equipment, during heavy rains when stored out of doors prior to being loaded on ships. Mosquito breeding was observed in tires on three of the ships. Tires in holds of the first ship examined contained an estimated 20 to 30 mosquito larvae per tire. Mosquito breeding was from medium to sparse on the remaining two infested ships. In addition to the larvae being present in the water in the tires, numerous adult mosquitoes were found in the holds.

Species of mosquitoes found in the tires on the infested ships, as reported by Pratt *et al.* (1946), were the following, all seven of which are non-indigenous to continental United States, and some of which have been incriminated in the transmission of disease to man: *Aedes scutellaris* (Walker) (as *Ae. scutellaris hebrideus* Edwards), *Aedes albopictus* Skuse, *Armigeres milnensis* Lee (as *Armigeres obturbans milnensis* Lee), *Culex annulirostris* Skuse, *Culex papuensis* Taylor, *Toxorhynchites* (*-Megarhinus*) species, and *Tripteroides* (near) *quasiornata* (Taylor).

Aedes scutellaris and *Armigeres milnensis* were recovered from most of the tires in the first shipment in which mosquitoes were found breeding; however, they were less numerous in the other mosquito-infested shipments. There was breeding by all of the species found in the tires, with exception of *Culex annulirostris* which was represented by one dead adult female.

Control measures were applied to the cargo of the infested ships to prevent escape of adult mosquitoes. Also, as the tires were removed from the holds of the ships, those containing water were treated with a DDT-kerosene solution. Unfortunately, in connection with the unloading of the first mosquito-infested cargo ship, three "box-type" freight cars were inadvertently loaded prior to applying DDT-kerosene solution to the tires which contained water. However, these three loaded railroad cars were treated with a Freon-pyrethrum aerosol and immediately sealed. Following arrival of the loaded cars at their destination, which was 40 miles from Los Angeles, they were again treated with a Freon-pyrethrum aerosol to kill any adult mosquitoes that might have emerged while the cars were en route. When the cars were opened for the purpose of examining the tires, living mosquito larvae were found in many of the untreated tires. Necessary control measures were then applied. In view of the number of times these tires were handled it is interesting that sufficient water remained to sustain living mosquito larvae. Also noteworthy is the fact that, in spite of two applications of an insecticidal aerosol containing pyrethrins, numerous larvae survived. Fortunately, there have been no reports of the establishment of any of these species in the United States as a result of these importations in tires.

Another example of mosquito breeding in tires which were being transported by ship was reported by Perry (1947). He stated that spray crews boarding ships arriving at Noumea, New Caledonia, during World War II encountered hordes of *Ae. aegypti* adults in the holds of a freighter, which subsequently departed for the United States with a cargo of salvaged tires.

Twelve larvae of *Culex quinquefasciatus* were found in a shipment of 200 bulldozer tires that arrived at Honolulu from Saipan during March of 1947. Bonnet (1948) reported that larvae of this species were present in approximately nine percent of the shipment of 200 tires, and that there was no doubt but that the larvae were of foreign origin. This appears to be the only record of mosquito larvae observed on ships or aircraft arriving in Hawaii in recent years.

Not only have mosquitoes been found in old tires being transported by ships, they have been found on two occasions in old tires transported on aircraft. In the first instance, more than 100 larvae of *Culex quinquefasciatus* were recovered from water in aircraft tires flown from Colombia to Miami, Florida, for recapping. Inspection of the tires by Public Health Service quarantine personnel at the Miami airport during August 1955 revealed the presence of *Culex quinquefasciatus* larvae in water in three of the old tires. The remaining tires contained no water. In addition to the *C. quinquefasciatus* larvae, adults of *Anopheles albimanus* Wiedemann (1, dead) and *Mansonia indubitans* D. and S. (7, dead) were found on the aircraft. Another cargo plane arrived at Miami from Colombia October 1955 with old tires in which three larvae of *C. quinquefasciatus* were found.

Whether being transported on ships, aircraft, or railroad cars, or whether lying in grassy yards or stacked in piles at junk yards, obviously old tires are often conducive to a high index of *Ae. aegypti* and other mosquitoes which adapt themselves to breeding in this type habitat. Actually, old tires would appear to constitute a more formidable enemy to mosquito control programs than did the old sailing vessels with their open water supplies.

Mosquito Breeding in Containers of Various Types on Ships and Aircraft. Occasional mosquito breeding, other than in tires, has been observed in various types of receptacles on aircraft and ships arriving at United States airports and seaports during the past few years.

In 1935 Oakley (personal communication) observed mosquito larvae in a barrel of water on a schooner which had arrived at Mayaguez, Puerto Rico, from a nearby island.

Two larvae of *Ae. aegypti* were found in a water barrel on a cargo motor vessel by Public Health Service personnel at Miami, Florida, November 1945. The vessel was carrying bananas to Miami from the Dominican Republic.

Larvae of *Ae. aegypti* were found in wooden fire buckets on the main deck of a motor vessel upon arrival at the quarantine station, San Juan, P. R., November 1950. The observation was made by a Public Health Service sanitary inspector during a routine sanitary survey of the vessel.

Four mosquito larvae were found in water contained at the base of the corolla of a bird of paradise flower (*Strelitzia* species) which was being carried by a passenger on an aircraft from Panama. The larvae, intercepted by an agriculture inspector at Miami, Florida, August 1952, were later identified as *Wyeomyia* species. In addition to the mosquito larvae, four *Psychoda* species larvae were found in the same flower.

COMMENTS ON DISINSECTIZATION AND ENTOMOLOGICAL SURVEILLANCE. Although comparatively few observations have been made during recent years on the accidental transportation of immature mosquitoes on aircraft and ships, it should not be concluded that this is altogether the result of lack of endeavor on the part of health representatives. Actually, most aircraft, ships, and other carriers arriving at United States ports and, for that matter, at ports in many countries of the world, are routinely inspected for presence of insects. A program of this nature has been pursued by the Public Health Service for many years (Hughes, 1949).

More than 28,000 aircraft arriving at United States airports from abroad during the 12-month period ending June 30, 1955, were given entomological inspection. These inspections revealed the presence of insects on 14.0 percent of the aircraft. A total of 703 mosquitoes were found. There were no records of mosquito larvae for aircraft during the 12-month period.

Also in the case of surface vessels arriving at United States ports, routine sanitation inspection is made, including a search for insects and rodents. The quarantine inspectors have been instructed to observe carefully for possible breeding of mosquitoes in receptacles on board these ships. Although numerous insects, including many species of mosquitoes, have been found on ships during recent years, nearly all have been in the adult stage. Also, substantially all of the mosquitoes found on these ships are indigenous to this country.

In addition to inspection of aircraft and ships for presence of arthropods, disinsectization procedures using insecticides and methods prescribed by Public Health Service regulation (Surgeon General, 1955) are employed as an aid in preventing the importation of viable arthropod forms. Further, as a second line of defense, an entomological surveillance program is routinely carried out in the vicinity of airports and seaports, particularly in the South, to ascertain the possible presence of imported mosquitoes or other public health species, and to apply control measures when needed.

The writers are not aware of the establishment of mosquitoes in the United States resulting from importation by aircraft or, in recent years, by ship. However, Mulrennan *et al.* (1945) reported on the finding of a fourth instar larval specimen of *Anopheles albimanus* on a military base at Boca Raton, Florida, in 1944. Apparently this larval specimen was the only one of its kind found as far north in Florida as Boca Raton. It was suggested that it may have been an offspring of a gravid female mosquito which may have been imported on an aircraft at the military base where found. Reportedly, an aircraft, for which there was no disinsectization record, arrived at the base from an *albimanus* area 16 days prior to the finding of the larval specimen. Although this mosquito did not become established at Boca Raton, the record serves to point

up the importance of maintaining disinsectization and entomological surveillance programs.

Conclusions. The most obvious conclusion warranted by the records presented in this paper would appear to be that, even in the near absence of the old sailing vessel, with its open water tanks and lack of sanitation, mosquitoes continue to adapt themselves to various niches even in the modern carrier, sometimes finding them not only favorable to their transportation but also for their propagation. Since this is the case, it may well be that immature stages of mosquitoes are being transported more often than is realized. In any event, we should remain constantly on the alert to prevent such importations, particularly in view of the emphasis that is being placed on mosquito control in this country and abroad, with attention being given to the possibility of reinfestation.

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RESEARCH NEEDS ON MOSQUITOES IN RELATION TO AGRICULTURE

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The purpose of this paper is to discuss some of the problems of pest mosquito control as they relate to agriculture. These problems must be considered in the development of a long-range program to reduce the annoyance and economic losses caused by these insect pests. Many of you actively engaged in mosquito research or control activities are much better informed than I on details of the many problems that need to be resolved in our continuing battle with mosquitoes. I will therefore limit my discussion to the broader aspects of the problems, specifically as they relate to agriculture.

Owing to the efforts of a number of members of this Association, the public is beginning to recognize the need for more support for research and control on pest mosquitoes. Several states are giving increased attention to such work, and legislation now before Congress provides for substantial support at the Federal level. Those who have brought this legislation to the current stage are to be commended. The importance of pest mosquitoes in terms of public comfort and health, losses to the livestock grower and other farmers, reduced real-estate values, and the millions spent on control programs justifies such support.

In the past, research on mosquitoes has been concentrated on their relation to public health. The work of Federal and State health departments, State experiment stations, and the U. S. Department of Agriculture, which has been working largely with funds provided by the military departments, has yielded outstanding results. Basic information on the biology, taxonomy, and ecology of most of the species has been obtained. The relationships between mosquitoes and most of the mosquito-borne diseases have been determined. Much has been accomplished in water-level management, many highly effective insecticides and repellents have been developed, and ways to employ them to achieve mosquito control have been worked out.

These and other developments have made it possible for health agencies to practically eliminate malaria, yellow fever, dengue, and other mosquito-borne diseases as vital factors in human health in this country. The information has also been of great value in controlling pest mosquitoes in urban areas, and control workers have organized many successful abatement areas throughout the country. However, in the research on pest mosquitoes the emphasis has been on their control in urban communities located in coastal or floodwater areas. Much additional research needs to be done on mosquito problems in such areas, and many urban communities need technical assistance in organizing control districts. However, the pest mosquitoes are also a serious problem in rural farming areas, especially those under irrigation. More and more land is being irrigated, and we all know that irrigation projects inevitably bring more pest mosquitoes which in turn may lead to disease outbreaks among man and livestock.

The mosquito problem in relation to livestock production has received very little attention. The need for investigations along this line has been stressed repeatedly by Lindquist (1954, 1955a, b, c). This problem is especially acute in irrigated regions, although it is also important in nonirrigated areas. The expansion of

grassland agriculture and the need for livestock-production practices that will bring greater returns to the farmer must be considered in both current and long-range plans for mosquito research. The lack of progress in the control of pest mosquitoes in rural areas is due to a number of causes. (1) The farmer is a rugged individual, and his demands for a solution to the mosquito problem are not as persistent as those made by people in urban areas. (2) It is more difficult to organize and obtain financial support for control programs in a rural community than in an urban area. (3) On the basis of current knowledge, control programs would add to the cost of running a farm. (4) The losses in productivity of meat, milk, and eggs caused by mosquitoes have not been determined. (5) The insecticides now commonly employed for mosquito control, when applied in agricultural areas, give rise to special problems less frequently encountered when they are applied on marshes and other wasteland areas; for example, their application to pasture lands and to forage crops creates hazards because of their potential toxic effect on farm animals and residues in agricultural products, including meat and milk. (6) The biology, habits, and ecology of mosquitoes that are primarily pests in irrigated areas are not as well known as those of the marsh and flood water species.

The following are some of the major lines of research that need to be initiated or expanded:

1. BIOLOGY, TAXONOMY, AND ECOLOGY OF MOSQUITOES. In spite of the knowledge we now have, investigations on these phases of mosquito research need to be intensified. The life history, habits, and relative seasonal abundance of various species in different areas should be determined. Careful study is needed to determine the relationship between mosquito populations and animal populations, livestock-management practices, types of forage and range crops produced, fertilizers employed, and other farming practices.

2. WATER- AND LAND-MANAGEMENT PRACTICES. From a long-range standpoint the proper management of lands and water, especially in irrigated areas, undoubtedly offers the greatest possibilities of reducing mosquito abundance at the lowest cost. Fortunately, proper land conditioning from a topographical standpoint, suitable drainage and irrigation canal systems, construction of farm ponds, and proper utilization of irrigation water are usually profitable from the standpoint of agricultural production as well as mosquito control. Details regarding proper practices in relation to mosquito production in different areas need intensive investigations.

3. DEVELOPMENT OF EFFECTIVE, ECONOMICAL, AND SAFE INSECTICIDES AND METHODS OF USE. Insecticides for mosquito control in agricultural areas must be low in toxicity to animals at applied rates and must not contaminate forage, meat, and milk with excessive residues. Recent passage of Public Law 518 (Miller Amendment) makes it necessary to conduct costly studies to assure that the residues will not exceed tolerance limits, before a new insecticide can be registered for interstate commerce and recommended for use where agricultural products might become contaminated. Such studies are already an important phase of programs under way by Federal and State agencies engaged in research on the control of insects on forage and other crops consumed by livestock.

The equipment used to apply insecticides in wasteland areas may not be the most satisfactory in farming areas. Studies on various methods of application are therefore desirable. For example, more intensive work on highly effective insecticides soluble or miscible in water and methods of dispersing them might materially reduce the cost and safety of mosquito control in irrigated areas.

The requirements for suitable insecticides for mosquito control in farming areas may necessitate a search for substitute insecticides.

4. EFFECT OF MOSQUITOES ON LIVESTOCK. Relatively little is known about the effect of mosquitoes on the weight

gains of beef animals, milk yields of dairy cattle and egg production in poultry. Such information at various mosquito-population levels and with different species is needed. Such investigations might well show losses to the livestock grower in a mosquito-problem area to be a major factor in his production costs and consequent reduced income. The benefit from the standpoint of animal production and health could be a vital factor in selling the need for community-wide mosquito-control programs even in areas where the primary purpose would be to protect humans from annoyance and disease.

5. DEVELOPMENT OF REPELLENTS OR INSECTICIDES FOR DIRECT APPLICATION TO LIVESTOCK. The most practical way to protect livestock from mosquito attack in areas where community-wide programs are not feasible or have not been organized is through the use of repellents or insecticides applied directly on livestock. Intensive studies along this line are urgently needed. The studies that have been conducted in the past and now under way on repellents for use by military personnel will complement similar investigations on livestock. Investigations on livestock must include the usual costly toxicological and residue studies in meat and milk now necessary in connection with the control of other external parasites. The adaptation of available military repellents for use by farm workers should also be provided for in any expanded research program.

6. BENEFICIAL ORGANISMS IN RELATION TO MOSQUITO ABUNDANCE. An investigation on the natural enemies of mosquitoes should be undertaken as a basis for utilizing them to the maximum extent possible in limiting mosquito production. The possibility of finding insect pathogens that can be used to destroy mosquitoes should be given special attention. It has been shown in recent years that a number of agricultural pests can be controlled by disseminating cultured disease organisms in the same manner as insecticides. This approach to mosquito control offers such great advantages over insecticides that a thorough exploration is warranted.

7. ROLE OF MOSQUITOES IN THE TRANSMISSION OF ANIMALS' DISEASES. Mosquitoes are vectors, or may be implicated in the transmission, of several diseases of livestock and poultry. Their importance in relation to anaplasmosis in cattle, blue tongue in sheep, leucocytozoon in poultry, fowl pox, filariasis in dogs, and other animal diseases should be investigated.

8. MODE OF ACTION OF INSECTICIDES AND MECHANISM OF RESISTANCE. The number of insects that are becoming resistant to insecticides and the number of insecticides involved are steadily increasing. The seriousness of this problem merits careful study to determine what materials and how they should be used to avoid or delay resistance.

In the development of a broad and comprehensive research program on the many facets of the mosquito problem, it will be advantageous to have the cooperation not only of investigators in many phases of entomology but also of specialists in other fields of science. The day that an individual researcher can successfully investigate all aspects of an important problem is past. We need specialists in entomology, chemistry, physiology, animal toxicology, engineering, soil and water management, and other fields to study the various aspects of the problem.

As the research progresses, mosquito workers should hold national or regional conferences of a round-table type to discuss the results of their work, new ideas, and future plans. Such conferences will fill gaps in an over-all research program, avoid duplication of effort, develop supplementary research programs when indicated, and often lead to more uniform control recommendations. Regular conferences of this nature are being held by Federal and State workers in several fields of entomology, with great benefit to all. For a number of years the Public Health Service, the Tennessee Valley Authority, and the Entomology Research Branch have held an-

nual meetings of this nature to discuss the various activities under way in the medical entomology field.

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ERADICATION OF THE *AEDES AEGYPTI* MOSQUITO FROM THE AMERICAS

OCTAVIO PINTO SEVERO, M.D.*

I—Technical Evolution of the Campaign

The discovery of jungle yellow fever gave rise to the idea of eradicating *Aëdes aegypti*. The results obtained in 1930 in the Rio de Janeiro campaign and those that were being achieved since 1923 by the Rockefeller Foundation in other Atlantic port cities of Brazil, led to the belief that the solution of the problem which arose with the discovery of the yellow fever virus in the South American forests would be possible only with the absolute eradication of the urban vector-mosquito of the disease, since the palliative control measures were no longer justified. Working standards were instituted on the basis of (a) wise administration; (b) strict execution of the measures recommended by experience, with the compulsory use of petroleum in all deposits with foci; (c) organization of supplementary services to discover residual foci, as indicated by the capture of adults, a method that was being used against malaria and thereafter became essential to the evaluation of the anti-*aegypti* work. With the use of these three basic measures, evidence was gained that *Aëdes aegypti* could be eradicated in Brazil with a few more years of work, if certain aspects of the problem that had been disclosed by experience were solved. The first revelation was that the success of the campaign in Brazilian port cities depended upon the application of the control measures to all other localities maintaining sea, river, or land communication with such cities, necessitating an extension of the work to the suburbs and later as far into the rural areas as *Aëdes aegypti* was found. There were regions in Brazil in which the mosquito had spread to such an extent, as was the case in the northeast, that it was necessary to cover such regions in their entirety, just as if they were a single "ever-increasing adjacent area."

Another difficulty that had to be overcome was the resistance of the *Aëdes aegypti* egg to desiccation and, in general, to temperatures biologically unsuitable to other species of mosquitoes. This resistance, which is known to reach 450 days in laboratory, amounts to an average of more than a year under natural conditions. This is one of the factors on which the criterion of *Aëdes aegypti* eradication is based, and we shall take up this point later. The

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campaign that was proceeding in Brazil under the guidance of the Rockefeller Foundation was not limited to that country alone. It was extended to Bolivia, Paraguay, Peru, and Colombia, giving the same good results and showing that the eradication of *Aëdes aegypti* was to be considered a project no longer limited to national boundaries but rather one continent-wide in scope.

In 1940 an event occurred that convinced even the most skeptical persons of the idea of eradicating a species of mosquito. *Anopheles* (*Myzomia*) *gambiae,* which came from Africa and was discovered in 1930 by Shannon at Natal, in Rio Grande do Norte, Brazil, had been poorly combated and succeeded in penetrating a vast area of that State and of the State of Ceará, causing great epidemics of malaria in 1938 and 1939 and creating a problem that to many malariologists seemed unsolvable. The vector was, however, conquered and eradicated in Brazil that year in a memorable campaign conducted under the guidance of the Rockefeller Foundation, using the same basic principles of organization and discipline and a large group of persons who had been working actively in eradicating *Aëdes aegypti.*

The strategy used against *An. gambiae* was planned according to the living conditions that the mosquito had to adopt in order to survive and spread in northeast Brazil, these conditions being very similar to those of *Aëdes aegypti* owing to the domestic habits of the adult and its preference for small collections of water. The attack was based on the systematic use of paris green in all collections of water, and on fumigation with a compound based on pyrethrum and carbon tetrachloride in a kerosene solution (PTQ). Repeated treatments were applied to all houses so as to eliminate the greatest number of adults possible, using a De Vilbiss sprayer quite similar to those used today in DDT sprayings. Inspection was maintained of innumerable collections of water that formed, and of pools that appeared in dry river beds and were used for irrigation or for watering animals. At the same time intradomiciliary captures were made in order to evaluate the results of the measures adopted. The eradication of *Anopheles gambiae* in Brazil demonstrated that the experience acquired and the personnel employed in the campaign against one insect vector of disease could be utilized in combating other vectors, an idea that anticipated the theory of coordinated campaigns which came about with the discovery of residual-action insecticides.

With the advent of DDT the time arrived to give more serious thought to the eradication of *Aëdes aegypti* on a continent-wide scale. With the withdrawal of the Rockefeller Foundation from yellow fever work, the Pan American Sanitary Bureau, which had undergone a complete reorganization in 1947, inherited the responsibility for the problem. It was evident that the point demanding first attention was the eradication campaign. On the other hand, it was realized that the program that had been under way in Brazil for a number of years could not achieve complete success unless the country's frontiers and ports were fully protected against constant *Aëdes aegypti* reinfestation. It became essential to pursue on a continental scale the work that had been done within the country. In other words, an attempt had to be made to extend the campaign to neighboring countries, all countries with which communication was maintained, until the threat of reinfestation disappeared.

DDT, used as a larvicide merely to substitute for petroleum, would have done little to advance the campaign. It was apparent from the start that DDT could be used systematically, because of its innocuousness to man in recommended dosages, in possible breeding sites with or without water as a protection against new foci, a protection achieved previously through complicated mechanical processes.

This method facilitated the use of the insecticide, since the worker had only to carry a container with the solution, emul-

sion, or suspension of DDT at 3 percent to 5 percent in order to make the application, but it has the disadvantage of attacking the mosquito only in its larval stage, thereby making little use of the residual action of the insecticide, for the organic matter usually found in home water deposits tends to reduce and even to eliminate its residual power. It was felt that the over-all application to the inside surface of dwellings, a method used in combating malaria vectors and certainly capable of eliminating all possibility of *Aëdes aegypti* survival, particularly when DDT is applied also to all the dwelling's containers would be too expensive and time-consuming in a campaign that, owing to its very nature, should be intensive and rapid. Therefore, preference was given to a process that was not so extensive or so expensive but could give effective results by using measures adapted to the biology of the *Aëdes aegypti*. It was thus decided that DDT should be applied in solution, emulsion, or suspension of from 3 percent to 5 percent, using a small sprayer, to both the outside and inside of all possible breeding sites, with or without water, and to a section of the nearby wall, so as to eliminate the existing foci and prevent the formation of other foci by destroying the female adults seeking to lay their eggs. This simple and economical method, which we call perifocal because it reaches the *Aëdes aegypti* in their microclimate, was adopted by the Pan American Sanitary Bureau beginning in 1948, after confirmation of its effectiveness in the field.

Experience has demonstrated that with the perifocal method, (a) one well-applied DDT treatment eliminates *Aëdes aegypti* from small localities (less than one thousand houses) where, generally, there is no problem of hidden foci or foci difficult to reach; (b) normally, two DDT applications during a year are sufficient to solve the problem in average localities (from one to five thousand houses); (c) four carefully made applications of DDT to all infested points in a large city (over five thousand houses), at intervals of three months, are sufficient to free it from *Aëdes aegypti*. An effort was made to adapt the campaign to new working standards developed with the use of DDT, taking the greatest advantage possible from the experience derived from petroleum. Since the action of DDT as we have used it provides safety for at least three months, it was possible to extend the minimal visiting cycles to that period, thereby effecting considerable economies in the campaign. Moreover, as the insecticides came to be used systematically in all possible breeding sites, with or without water, providing an even greater margin of safety, it was possible also to make a considerable reduction in the complementary services concerning closed and uninhabited dwellings, and almost to discontinue the special inspection of inaccessible deposits, control of cemeteries, and cleaning of vacant lots. Nor was it necessary to maintain the compulsory application of the law by the use of writs of infraction and fines, other than for those cases in which permission was not given to make house inspections and appropriate applications of DDT.

Other measures that have gained even greater importance with the use of DDT are the search for breeding foci difficult to reach, making captures that lead to such foci, and the compulsory use of the capture method as the final word in proving the eradication of the species in urban areas.

Another important modification that did much to simplify former ideas in this regard, was in the method of determining indices, which formerly were in every third house in all city blocks in the locality, whereas today it suffices to check every third house until the first positive one is found in each block. In small localities in rural areas it is sufficient to find one focus in order to determine what measures should be taken to eradicate the *Aëdes aegypti*. The new system adopted in this regard does not permit learning the degree of infestation, but it is sufficient to serve as a guide for using DDT.

With the reduction of the complementary services and practical discontinuance

of the special services, the number of forms used to record data and to note down the measures taken was greatly decreased. From the more than one hundred forms used previously, less than ten essential ones are now being utilized.

Requirements that have not been relaxed but have been made even more rigid are those referring to the use of sketches and itineraries to direct the work in the field, to the need for demarcating work areas for each inspector, and, particularly, to the repeated and timely check work carried out not only by the chief inspectors but also by the chief or director of the campaign. The requirement also stands with respect to the use of flags to indicate the presence of an inspector or chief inspector in the house being worked and, in addition, the field personnel still must use uniforms to facilitate their work and to permit their ready identification.

After some years of experience in campaigns based on DDT, it was possible to formulate standards governing techniques and evaluation of results, these being contained in the "Guide for the Preparation of Reports on the *Aëdes aegypti* Eradication Campaign in the Americas," distributed by the Pan American Sanitary Bureau in January 1954 which is being revised now. This Guide describes the two basic reporting forms, a monthly one containing data for publication in the Bulletin of the Pan American Sanitary Bureau, and a quarterly form showing data on the initial and the present conditions in all localities found with *Aëdes aegypti* in each country. With such data it has been possible to evaluate correctly the results of the anti-*aegypti* campaign in the countries and territories where work is under way. A direct appraisal of the activities is made by advisers and inspectors maintained by the Pan American Sanitary Bureau in the countries to instruct the local personnel and to follow up and intensify the work.

The culminating result of the use of the aforesaid standards and of the experience we have gained with the development of the anti-*aegypti* campaign in the Continent, is the criterion established for proving the eradication of the mosquito, which, along with general lines, can be described as follows: Taking as relevant factors the average period that the mosquito egg resists desiccation, or about one year, and the probable duration of the residual action of DDT, estimated at three months, it has been proved that it is necessary to repeat the examination of the results in cycles, according to this residual action and within the average period that the egg is resistant. This procedure has in view to discover possible flaws in the techniques used and to permit greater reliability in the data presented, especially when the last examination is confirmed by search for capture of adults at the time the search for foci is made, in accordance with the standards adopted.

The eradication criterion for urban areas where the *Aëdes aegypti* finds all conditions favorable to survival should be as rigorous as possible, and there should not be less than two consecutive negative checks, through search for foci and for capture of adults, so as to confirm the absence of the mosquito for a period of at least one year after the last focus or the last adult was found.

In rural areas where living conditions are usually very precarious for *Aëdes aegypti* and there are no problems concerning breeding places difficult to reach and ovular resistance can be overcome relatively easily, eradication should be confirmed after a negative check by foci search in the total number of houses at least one year after the last focus was found in the area.

Taking into account the data that are presented by the various countries and the direct appraisal of the field work, a periodic evaluation is made of the results obtained in the anti-*aegypti* campaign in the Americas, with a view to intensifying and improving it and to proving the eradication of the species according to the established criterion.

II. ACTUAL STATUS OF THE CAMPAIGN

The progress made in the *Aëdes aegypti* eradication campaign in the Continent is reflected in the attached map, based on reports until December 1955 and on first-hand observation of the problem in each country. The results can be summarized as follows:

SOUTH AMERICA. The vast area in eastern and northeastern Brazil treated for many years with petroleum, was shown in 1952, after four years of systematic DDT work, to be almost completely clean, and only the final checks are lacking to prove eradication of *Aëdes aegypti* throughout the country. The problem in Brazil, because of the country's area and the existence of conditions favorable to the mosquito, undoubtedly represents one half of the problem in the Continent. Bolivia, in 1948, was the first country to be freed of the mosquito; French Guiana followed in 1952. Chile, Ecuador, British Guiana, Paraguay, Peru, and Uruguay, in that region of the Continent, are in the final stages of eradication. Argentina is now organizing a nationwide campaign. In Colombia and Venezuela the work continues and is being intensified in Venezuela after the recent jungle virus threat. Surinam is the only part of South America where the campaign has not yet been started.

CENTRAL AMERICA. Subject to the results of the last checks now being made, Panama, Nicaragua, Costa Rica, Honduras, and British Honduras can be considered to be in the final stages of their campaigns. The campaign was intensified recently in El Salvador and Guatemala and the final stage should be reached next year. *Aëdes aegypti* is considered to be eradicated in the Panama Canal Zone (U.S.A.), although no statistical data are available to corroborate this fact.

GREATER ANTILLES. Generally speaking, the situation in these islands is still not satisfactory. Cuba, where the idea of combating *Aëdes aegypti* originated, is quite infested as was revealed by the first results of the campaign initiated in March 1954. In the Dominican Republic the situation is better in the interior than in the capital, where it has not yet been possible to apply all the necessary measures. Nor has Haiti succeeded in developing a rapid plan of work. Jamaica is still infested, but measures are being taken to improve the campaign. Good results are being obtained in Puerto Rico with the measures adopted to accelerate the eradication of *Ae. aegypti*.

LESSER ANTILLES. In most of these small islands the campaign was initiated recently and there is a trend to extend them to the others. They include thirteen archipelagos, in ten of which *Aëdes aegypti* work is already being conducted, although not always in satisfactory fashion. With respect to the spread of the mosquito, Trinidad, Tobago, and the Netherlands West Indies (Curaçao, Aruba and Bonaire) are the most important points and they are now adopting measures that should result in the speedy elimination of the *Aëdes aegypti*. In Trinidad an outbreak of yellow fever occurred in 1954, when the virus invaded Port-of-Spain, producing *Aëdes aegypti*-transmitted cases, a situation that had not occurred in the Americas for over twelve years.

NORTH AMERICA. In Mexico, the campaign was interrupted in 1955 but it is possible that it will soon be resumed. There are large infested areas in that country, particularly in the Yucatan Peninsula and along the Atlantic and Pacific coasts. It is expected that the recently initiated malaria-eradication campaign, with the application of DDT to large areas where the two problems coexist, will contribute much toward eliminating *Aëdes aegypti*.

Special reference should be made to the United States, the only country that has not initiated an *Aëdes aegypti* eradication campaign. Ponderable reasons, some acceptable, others unjustifiable, have been postponing the start of the campaign in this country, which is in a position to carry it out quickly and brilliantly. The problem has more of a psychological basis and is difficult to solve from a political

PROGRESS OF AËDES AEGYPTI
ERADICATION CAMPAIGN AS OF
31 DECEMBER 1955
AREAS IN WHICH AËDES AEGYPTI IS STILL PRESENT
AREA DECLARED RECEPTIVE TO YELLOW FEVER BY U. S. PUBLIC HEALTH SERVICE
AREAS IN WHICH AËDES AEGYPTI IS NO LONGER FOUND

FIGURE 1

viewpoint. In view of the vast area considered as yellow-fever receptive by the Public Health Service, an area that includes parts or all of thirteen states in the south of the country, the task would be a difficult one to undertake, particularly in its initial stage, but there are many factors that tend to facilitate the campaign. Among them we can point out the interest being shown by the Communicable Disease Center and the willingness of the Government to make a study of the problem, beginning at the important seaports.

In the meeting of last November in Kansas City the American Public Health Association approved a resolution urging that "the United States Public Health Service and the State Health Departments take immediate steps to initiate programs directed toward the eradication of *Aedes aegypti* mosquitoes from the United States." This campaign, more than ever before, needs for its rapid conclusion, that a favourable decision be taken by the sanitary authorities of this country.

Last year in the meeting held in Panama City, Florida, the Director of the Pan American Sanitary Bureau emphasized the importance of the support of this Association and the members of the Association, not only for such things as the eradication of *aegypti* but also for other functions such as international organizations, part of the general world movement of better international understanding. It is with this purpose in mind that I address you now, certain of the great interest that this campaign has aroused and also of the support of all members of this Association.

YELLOW FEVER IN TRINIDAD—A BRIEF REVIEW

H. P. S. GILLETTE

Trinidad is the senior partner in the British Administrative set-up known as the Crown Colony of Trinidad and Tobago. The island is situated between 10° 3′ and 10°44′ north latitude and 60°55′ and 61°44′ west longitude and has an area of 1863 square miles. Its greatest length is 50 miles from north to south and greatest breadth 32 miles from east to west. It is roughly rectangular in shape with large narrow promontories on the northwest and southwest and lies, at its southwestern end, but seven miles from the Venezuelan coast. Its capital is Port of Spain, with nearly 120,000 people out of a total population of roughly 670,000 persons for the entire colony.

Geologically the island compares with the structure of the adjacent South American coast and consists almost entirely of sedimentary rocks. In ancient times the island probably formed part of the delta of the Orinoco and in the northern portion of the island there is considerable faunal and floral affinity with the fauna and flora of the Orinoco. According to R. C. Marshall (1) the island can be divided into five main belts and is considerably wooded, particularly in the northern range of mountains which possesses two peaks of over 3,000 ft. each.

The island has a tropical climate and apart from a well defined dry and wet season shows little climatic diversity. The rainfall ranges from between 50″ to 60″ in the flat coastal lands to over 120″ in the hills.

The forests in many localities abound normally with monkeys, there being two species, *Alouatta seniculas insulanus* Elliott or howler monkeys and *Cebus apella* Linn, the capuchin or white faced monkey.

Yellow fever was long considered absent from the island, the last reported

cases having occurred in 1914 in a rural area and the last urban outbreak in Port of Spain in 1907.

Scott (2) lists the outbreaks in the West Indies from the year 1493, five years before the discovery of Trinidad by Columbus, the first outbreak in Trinidad being given as the year 1796–97. It is more than likely there was yellow fever prior to this as the neighbouring islands of Barbados and Grenada have histories of yellow fever as far back as 1646. Since 1796 outbreaks occurred in 1818, (1820 in Tobago with an 80 percent mortality), 1828 (13 percent mortality), 1838, 1858, 1869, 1889, 1891, 1894, 1906–07, 1910–11 and 1913–14.

The Annual Reports of the Surgeon General (3) for the years 1906–07, 1907–08, 1908–09, 1910–11, 1913–14 give full details on the occurrence of yellow fever during these periods. In the outbreaks of 1906–07 there were 24 cases with 11 deaths, it being reported that the later cases were generally of milder type (3). Of the first five cases, four proved fatal and were persons who had lived less than 2 years in the West Indies—a most significant feature, which he analyzes in his reports of the next year. The following table is taken from this report.

Total Cases	Sex		Av. Age		Race			Deaths		Recov.		Death Rates	Percent D.R.	
	M	F	M	F	Wh.	Col.	Blk.	M	F	M	F		M	F
47	32	15	25.9	23.46	40	5	2	18	10	14	5	59.57	56.2	66.3

(Only 10 of the cases were natives of the West Indies)

In an earlier report the Surgeon General comments on the proximity of Venezuela and the fact that there was no obligation on the Venezuelan authorities to certify this infectious disease. Special powers were obtained in March and April 1907 and amended in January 1908 for the purposes of improving sanitary conditions and destroying mosquitoes, and in the light of present situation his bitter criticism which states: "In this connection the importance of individual efforts in co-operation with Sanitary Authorities can scarcely be over-estimated and it is surprising, and a matter for regret that persistent practical demonstration and instruction by the Sanitary Staff appear to arouse so little personal interest and sustained effort towards the protection of the individual and the community from the extension of the disease," was equally applicable in 1954.

Only three cases occurred in 1908–09 (2 deaths). All were males and resided from 5–11 months in Trinidad, one was English, one German and one American. The following year there were two cases reported and both died, both young males 18 years of age, and both born in Madeira. In the light of our present knowledge one wonders at this stage what the real morbidity of yellow fever was during these years in question.

Finally there was an outbreak at Brighton in 1913 (4). Ten known cases occurred and three died. Of these ten cases, only one, a planter, had spent more than two consecutive years in Trinidad and except for him all were Americans.

It is interesting to note that Balfour (5) refers to dead monkeys in connection with the 1913–1914 outbreak mentioned above and speculates upon their connection with the disease. He was the second person to refer to dead monkeys in Trinidad in connection with yellow fever outbreaks, Charles Kingsley (1871) in his book "At last, A Christmas in the West Indies" being the first.

THE PRESENT OUTBREAK. During 1953, the Trinidad Regional Virus Laboratory took samples of blood from the inhabitants of the Manzanilla, Biche, and Sangre Grande areas lying at the eastern foothills of the Northern range. A number of the blood samples neutralised yellow fever virus, and in view of the fact that the ages of the individuals varied from 15 years to

40 years it would appear that yellow fever (undiagnosed and unrecognized) had been present in Trinidad since the last outbreak in 1913 (4).

On April 22nd 1954 an agriculturist of mixed blood living in Cumaca, a village nestling among the foothills of the north-eastern end of the northern range, was admitted to the hospital at Arima. A sample of blood was obtained the same day by the Virus Laboratory. Pending the result the patient was treated as a case of malaria. His illness was mild and he made an uneventful recovery. His blood neutralised yellow fever virus. This was the first case of undoubted yellow fever since 1914 and the serological findings are discussed by Anderson, Spence and Downs (6).

A period of three months elapsed without any further cases coming to light, but during this time there were reports from hunters that the bodies of dead monkeys were being discovered in the forests. Then between 27 July 1954 and 6 October 1954, fourteen additional cases were reported from various parts of the Colony. Of the total of 15 cases, 4 died. With one exception all cases occurred in areas adjacent to forest or in people who had recently been in the forest. This exception was a patient—a young woman—who denied having ever left Port of Spain for some time, and under these circumstances the probability of *Aedes aegypti* being involved was considered.

Yellow fever virus was isolated on several occasions by the staff of the Trinidad Regional Virus Laboratory from *Haemagogus* mosquitoes collected in the forest of Melajo and Charuma. *Haemogogus* mosquitoes have also been collected in wooded suburbs of Port of Spain.

Aedes aegypti were extremely prevalent and in most areas in the island the indices were very high. In 1948, in the course of routine mosquito investigations, the staff of the Malaria Division, Health Department, Government of Trinidad and Tobago, had been alarmed at the high densities of *Aedes aegypti* found and instituted an island wide compilation of *aegypti* indices. As a result it was recommended that an *Aedes aegypti* eradication program be immediately embarked upon, but like so many other public measures that do not strike with immediate and spectacular urgency, the matter was shelved. In the light of the subsequent demonstration of resistance in *Aedes aegypti* to DDT, it is interesting to speculate what would have happened to this mosquito if eradication measures based on DDT had been executed 6 years before.

Measures Adopted—A. The Early Years. Prior to the discovery of the role of the mosquito in yellow fever transmission, cases of the disease were treated, or rather neglected, and frequently shunned either in hospital or at home. In severe epidemics, large sections of the population fled and but too often the dead were left to rot for several days.

In the 1906–1907 epidemic, on diagnosis of a case, the patient was isolated, usually in hospital, and screened. His house and adjoining premises were fumigated and the neighbours kept under surveillance. In addition, the staff of Sanitary Inspectors was augmented and an attempt made at better inspection and cleaning of yards.

In 1907 and 1908 special powers were obtained by the Health Department. These powers were aimed to improve sanitary condition and called for the extensive destruction of mosquitoes. Prosecution of offenders was rigorously undertaken and in 1911, 473 informations were laid for breach of Mosquito Regulations and BWI $555.72 was levied in fines (5).

In 1912 there were 129 prosecutions with convictions obtained in almost all cases and the fines realised $151.08 (6).

In the Brighton outbreak of 1914 the differentiation between jungle and urban yellow fever was appreciated and in addition to re-screening and fumigating the Company houses and oiling all stagnant water, it was suggested:

(1) To allow no non-immune to go to the forest for a period of 5 weeks since the last case;

(2) To cut down and clear the forest 100 ft. on each side of the main road through the oil field (5 miles);

(3) To clear the forest for a radius of 900 ft. from the center of each well or field;

(4) To burn brush and drain the exposed area;

(5) To build screened barracks for native employees.

B—1948–1954. Reference has been made to the proposals put forward in 1948–1950 for the eradication of *Aedes aegypti*. Though this scheme was rejected, a token vote was eventually provided to control the high indices found in the island survey executed between 11th September and 4th December, 1950.

The area selected for this token project was the most thickly populated area of the island with Port of Spain as the center. All water containers both outside and inside premises were treated with a suspension of 25% wettable powder DDT at the rate of 1 drop per gallon of water. We were assured by experts that this treatment would kill all *Aedes* larvae and have a residual action for a considerable period of time and that two or three cycles of such treatments would eradicate the mosquito. Immediately on the commencement of the program, the field staff led by Dr. F. R. S. Kellett and Sanitary Inspector Carlton Gilkes, found that this was not so. Larvae in barrels and drums refused to exhibit total mortality and in those few cases in which a container had had all its larvae killed, fresh breeding was found in 12–14 days. Larvae that had been exposed in the field to a sufficient dosage of DDT were successfully bred out into adults in the laboratory and as a consequence, much time was consumed in a thorough review of techniques both in the laboratory and in the field. Dosage of containers was considerably increased but even when carried to the maximum safe limits, total mortality was absent. Advisors and experts came and went. No serious fault could be found with the techniques and the matter had to be dropped owing to lack of funds.

1954–1955. The finding of the Trinidad Regional Virus Laboratory regarding the neutralising of yellow fever virus by the serum of certain people in the Biche, Manzanilla, Sangre Grande area was communicated to us at the end of 1953. Two capture stations were set up by us in this area and bi-weekly human bait captures of mosquitoes made. On one occasion only was *H. spegazzinii* captured, the prevalent species taken being *Mansonia mansonia, M. titillans, An. oswaldoi* and many *sabethines*.

The report in April 1954 of undoubted cases of yellow fever galvanised the whole island into activity and the following steps were taken:

1. An island-wide project to inoculate all persons with yellow fever vaccine;
2. An increase in the personnel to carry out island-wide DDT residual spraying;
3. The immediate formation of anti-larval teams to cover the island;
4. The assistance of PASH to supply advisers, DDT and vaccine;
5. Legislation for the compulsory treatment and spraying of premises.

By 23rd September, the antilarval teams were at work—a motley collection of spray cans were pressed into use, but by the end of October, all were equipped with Dronwall P.3 spray cans.

In spite of our forebodings and previous experience that only concentrated and short frequent cycles in anti-larval treatment could achieve results, we were assured that a single island-wide treatment of 75 percent wettable powder DDT at 1 drop per gallon of water would achieve eradication.

Eradication by these means was never had in any single area. There was a diminution in the *Aedes* indices beyond the critical densities and this dimunition coupled with vaccinaiton and residual DDT house spraying of every house in the colony were without doubt the main factors in preventing a severe epidemic of yellow fever. The importance of the early discovery of the disease together with the

assiduous watch kept over any new case of fever reported by the Trinidad Regional Virus Laboratory cannot be over-estimated.

DDT suspensions were succeeded by or combined with DDT emulsions. Dosages were stepped up and every flaw, no matter how minor, eliminated in our techniques. Nevertheless, total mortality could not be achieved and fresh breeding regularly appeared in treated containers.

Laboratory investigations proved what was suspected, namely, that resistance to DDT had occurred in *Aedes aegypti* thus shattering the position of this mosquito as the classic suspectible to the chemical. Colonies of local strain of *Aedes aegypti* were established at a field insectary and at the laboratory and DDT in up to 200 parts per million failed to kill larvae in 48 hours. This has been reported upon in our Annual Report for 1954.

In June 1955 we were requested by Dr. Fay, Ent. U.S.P.H.S., Savannah, Georgia, for a supply of *Aedes aegypti* eggs for the purpose of testing the mosquito for resistance to DDT and other insecticides. We have had no official report yet but a personal communication from a member of the Trinidad Regional Virus Laboratory informed us that the larvae and adults hatched from the eggs supplied were highly resistant to DDT.

Our laboratory testing of larvae showed that there was practically no resistance to BHC and dieldrin and as a result, the larviciding teams are now using BHC in the form of dispersible powder P.520 and emulsion concentrate containing 20 percent gamma BHC, and the results to date with this insecticide have been good. If resistance to this insecticide does not develop, *Aedes aegypti* will be eradicated from Trinidad and Tobago.

SUMMARY. A brief review of the occurrence of yellow fever in Trinidad is presented with special reference to the 1954 outbreak and the measures adopted then to control *Aedes aegypti* which had developed resistance to DDT formulations.

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THE MANAGEMENT OF WATER FOR MOSQUITO CONTROL IN THE COASTAL MARSHES OF FLORIDA

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Water management in one form or another has been practiced from the very beginning of "preventive" mosquito control measures. It constitutes the basis for all control planning, and any adaptations, whether it be drainage, water level fluctuation of impounded waters, diking and dewatering, diking and flooding, or hydraulic filling, are for the sole purpose of preventing the development and emergence of those lowly insects that plague mankind and hinder the economic development of the country.

Our subject therefore is not a new one; much has been done in the past and much has been learned. In the field of salt-marsh mosquito control, however, relatively little has been done due to the magnitude of the problem, insufficient funds, and also because the salt-marsh mosquitoes are not considered vectors of disease. The magnitude of the problem confronting us can be realized only if we consider the thousands upon thousands of salt-marsh acres along the eastern, southern, and western boundaries where it is now impossible to attempt control measures.

During the 1930's, in some locations, extensive salt-marsh ditching programs were carried out with hand labor under the W.P.A. program. The benefits derived are not questioned, but few, if any, districts today could afford to maintain these ditches with hand labor. Although these drainage programs in years past were generally successful in accomplishing their objective, the question arises as to whether they were as effective as they could have been. Was drainage the most economical method of water management?

Research scientists in the mosquito control field are at present unable to answer many questions vital to controlling the salt-marsh species of mosquitoes. When these facts become known through their diligent studies it will be possible to plan and execute preventive control measures with far greater proficiency than at present. The feasibility of salt-marsh mosquito control is of vital interest to many of you in attendance at this convention, and we would like to present a brief summary of what is being done in Florida to combat salt-marsh breeding through water management.

As many of you know, mosquito control programs in Florida are carried out by districts and counties, all of which are now receiving state aid funds and technical assistance through the State Board of Health. The program thus in some respects becomes a joint endeavor between the districts and the Bureau of Entomology in planning and execution of control measures. There are now 46 counties and districts in Florida with a total current budget of local and state funds amounting to approximately $3,273,000 for arthropod control.

Florida's tidal shoreline distance totals 8,426 miles; about three and one-half times the distance from Washington, D. C., to San Francisco. Over 15 percent of the total acreage in the State is marshland. Of the total 5,900,000 marshland acres, an estimated 700,000 acres are considered capable of producing salt-marsh mosquitoes. Studies have shown that in some areas of the state as many as 113,000,000 salt-marsh mosquito eggs are present per acre. No point in Florida is over 70 airline miles distant from either the Gulf of Mexico or the Atlantic Ocean. Of the 36 coastal counties, 30 have mosquito control programs and are expending approximately two and three quarters million dollars this year for mosquito control. The remaining six

counties not participating have a very small population and are not financially able to undertake the work.

In these thirty coastal counties the equipment for executing preventive measures consists of 37 draglines, 1 crawler-mounted Gradall excavator, 6 bulldozers, 3 backhoes, and 4 10-inch hydraulic dredges, plus pumps, trucks, and other incidental equipment. Our principal salt-marsh mosquitoes are *Aedes taeniorhynchus* and *Aedes sollicitans*. In addition, throughout most of the southern half of Florida, sand flies (*Culicoides sp.*) are frequently as much of a nuisance as mosquitoes.

Suffice it to say that each county and district carries out temporary control measures when necessary and great sums of money are expended in this manner. It has been interesting to observe during the past year or two the increasing resistance to chemicals which has seemingly developed in mosquitoes breeding in certain localities, and the interest in "preventive" control measures that has been aroused in some directors after miserable failures in controlling mosquitoes with insecticides.

The "preventive" control program began in earnest during the latter half of 1953 when the legislature made funds available specifically for this type of work. Emphasis has been placed on controlling arthropod production in the salt-marshes, and in this connection several variations of water management are being employed. These are: (1) ditching, (2) diking and flooding, (3) diking, (4) hydraulic filling, (5) vertical drainage, and (6) deepening and filling.

Machine Ditching. This method is familiar to all of you and there probably is nothing we can say about this type of operation that would be new to you. All ditches are dug to a minimum elevation of at least 1.0′ below mean low water in order to maintain tidal water at all times, are sufficiently wide to maintain an open flowing ditch after final bank settlement, and dead ends are avoided as much as possible. Draglines are normally employed for this work; however, two or three districts employ a small backhoe, mounted on a tractor for small, narrow ditching in marl in conjunction with their dragline operations. Double ditching is avoided where possible, but in some of the abandoned farm areas of southern Florida it is necessary to maintain a system of double ditching.

Diking and Flooding. In opposition to diking and dewatering for *Anopheles quadrimaculatus* control, the control of salt-marsh mosquitoes, and sand flies apparently can best be controlled through diking and flooding. Ditched salt-marsh areas can, on occasion, become heavy producers of sand flies which can become as much of a pest annoyance as the mosquitoes which were prevented from breeding because of the drainage work. Two years ago two areas totaling approximately 80 acres were diked and flooded for the purpose of observation and study. The dikes were constructed on all four sides of the area, sand and mud being excavated directly from the marsh and placed upon the salt-marsh vegetation to form the dike. It was desired to ascertain, among other things, if the dike would hold water without preparing the dike foundation by stripping the vegetation in advance of placing the dike material. This method was successful and resulted in a considerable savings in construction costs. The normal tidal variation in this locality is less than one foot between high and low, so a portable 24″ pump was used to flood the diked marsh to a depth of approximately one foot. This was done in May and no additional pumping was required that year. A high minnow population was naturally maintained within the diked area, and if any oviposition did occur around the unsubmerged margins of small island areas, the mosquito larvae apparently failed to reach maturity.

Based on observations made in these areas, it was concluded that this method of control offered possibilities for rapid control of both mosquitoes and sand flies at a far less cost than by ditching or filling. This would be true if extensive pumping was not required. Advantage could be taken of tides to flood the areas in many

localities, and pumping could be disregarded.

DIKING. On the basis of data and observations obtained from the two diked and flooded areas, plans were made for diking and flooding hundreds of additional acres last year. Work proceeded rapidly according to plan except that some areas were not flooded after completion of the dikes. Personnel were not available to carry out as complete observations as would be needed for drawing definite conclusions as to the benefits, if any, obtained from areas diked but not flooded. A detailed study will be made this year on these and other such projects.

The observations that were made seemed to indicate that very little breeding occurred within these diked but unflooded areas. There are at least three logical reasons why this actually may have occurred. (1) There were numerous permanent bodies of water within the dikes that supported a large minnow population. (2) Spring tides were prevented from intermittently flooding the marsh about every three weeks, and (3) the rainfall was probably a little under normal.

On those areas that were initially flooded after the mosquito breeding season began, it was necessary to apply larvicides to control the first brood of mosquitoes emerging from eggs deposited in the marsh area. This was foreseen and expected. No trouble was experienced subsequent to the first brood, and it is believed this can be avoided in the future when it is possible to take advantage of the high fall tides to flood the area initially.

The observations made last summer in the diked and unflooded areas, although certainly not adequate, have led us to revise the working procedure formerly followed in the construction of diking and flooding projects. Since it is possible that data obtained during this next season may show there is very little additional benefit to be obtained through construction of a dike on the landward side of the marsh, this portion of the work is being deferred pending the obtaining of additional data. Work is continuing on the construction of dikes on the shoreward edge of the marsh as the first phase of this work. The dike is tied into high ground at intervals in order to form cells which may later be of value if flooding is indicated. Evidence to date seems to indicate that the shoreward dike will keep spring tides from intermittently flooding the marsh and that rains will not present a serious problem. If such is proven not to be the case, then the landward side dike will be constructed and the area flooded. During the past fiscal year ending on September 30, 1955, a total of 8,162 acres had been diked at a cost of $6.21 per acre. This is only a fraction of the cost that would have been incurred for ditching, or filling, on an acreage basis.

As has been previously pointed out, there is insufficient data available at present to answer many questions that arise concerning the effectiveness of this type of work. In addition to the observations that will be made in areas previously constructed, observations will be made on a specially selected area of about fifty acres on the west coast. Two areas will be diked and compared with three adjacent control areas. The occurrence of breeding will be correlated with tide and rainfall in the hopes of establishing a definite relationship in the diked areas as compared with the natural marsh control areas.

HYDRAULIC DREDGING. Three adjacent counties on the east coast of Florida have each been operating one 10-inch hydraulic dredge, in addition to other equipment, for filling the salt-marsh breeding areas. An additional dredge was purchased by one of the three counties and delivery made in January of this year.

Hydraulic filling, properly executed, is a permanent method of building out mosquito and sand fly breeding areas. Improperly executed, conditions may be created that nullify any filling work done. The three dredges during the last fiscal year pumped 1¼ million yards of material and eliminated 430 acres of breeding area. The material is placed to maximum elevation only high enough to insure the fill being above normal spring high tides,

and with adequate slope for drainage. This elevation is not sufficiently high for property developmental purposes and the developer would have to add more fill dirt before the property would be suitable for residential property.

Vertical Drainage. The southern tip of Florida presents many problems in mosquito control due to the rock formation encountered. The Florida Keys are composed almost entirely of rock and coral, ranging from very hard flintlike rock in the eastern and central portion of the Keys to fairly soft rock on the western end at Key West. Ditching, diking, or filling is not generally feasible due to the absence of earth. Most of the breeding areas are saucer-like in formation and drainage has been satisfactorily accomplished to a limited extent by blasting through an overlying impervious rock stratum and permitting drainage into an underlying pervious stratum. Where the elevation of the breeding area is above the tidal level the areas will drain sufficiently to prevent mosquito breeding. In those areas below the tidal elevation it is noted that fluctuation of the water level occurs with the tides although there may be some time lag. This method holds promise for correcting a great many areas in the Florida Keys and it is expected that vertical drainage will be employed considerably in this area in the future.

Deepening and Filling. A limited amount of work is being performed with draglines and bulldozers in deepening and filling of small salt-marsh breeding areas. The principle involved is to deepen one portion of the breeding area to a depth sufficient to maintain water at all times, and to utilize the excavated material to build up the remaining area to sufficient elevation to prevent water remaining on the area.

Conclusion. Continual research work is being carried out throughout our nation in an effort to obtain more information on the habits of mosquitoes and the best ways of controlling them. Many ways are now employed; some of them good and some not so good. Through research and the ultimate development of means for economically and permanently controlling mosquito breeding sources, the mosquito nuisance can be greatly reduced with a saving of thousands of dollars now expended for repetitive measures.

MOSQUITO CONTROL IN NEBRASKA—PAST, PRESENT, AND FUTURE

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Nebraska claims more miles of streams of running water than any other State in the Union. It also has many lakes and marshes, with more than 2,000 lakes in the Sandhill Region alone. The first irrigation ditch in Nebraska was built in 1866 and the first irrigation district, the Farmers' Irrigation District of Scottsbluff County, was started in 1887. Today we have approximately 750,000 acres under ditch irrigation and untold acres under well irrigation.

Not until 1939, when Dr. H. Douglas Tate joined the staff of the Department of Entomology of the Agricultural Experiment Station, was there serious interest in mosquitoes. Previous to Dr. Tate's arrival, mosquitoes were considered pests

which simply must be endured. True, the only mosquito-borne disease recognized in Nebraska previous to 1940 was malaria and that was extremely rare. Therefore, mosquitoes attracted little attention from entomologists, public health workers, or the medical profession.

In 1942, Dr. Tate and one of his students, W. W. Wirth, published the first paper on Nebraska mosquitoes entitled "Notes on Mosquitoes in Nebraska," in *Entomological News*. The 1940's proved to be important for the development of mosquito studies in Nebraska.

Dr. W. McD. Hammon and his coworkers, especially Dr. W. C. Reeves, made several trips into the State in the early 1940's studying the relationship of mosquitoes to western equine encephalomyelitis. In 1943, they succeeded in isolating the Western equine virus from a a specimen of *Culex tarsalis* taken in eastern Nebraska. In addition, they found that the ring-necked pheasant was one of the reservoirs for the disease.

In June, 1944, Dr. Tate and another of his students, Doris B. Gates, published *The Mosquitoes of Nebraska* which appeared as a research bulletin of the University of Nebraska Agricultural Experiment Station. In this work, which was based on light trap records for 1942 and 43, they took approximately 250,000 mosquitoes which represented 33 species. Their work showed that *Aedes vexans* was the most abundant species, followed by *Culex tarsalis*. By and large these studies also showed that the anopheline mosquitoes were of minor importance in the State.

During the war years, the Office of Malaria Control in War Areas of the United States Public Health Service under the direction of Dr. John A. Rowe of the Kansas City Office of the United States Public Health Service, was active in Nebraska around military establishments and prisoner-of-war camps. This group was able to show that except in the extreme eastern part of the State, anopheline mosquitoes were rare or absent. However, they felt that there were sufficient numbers of *Anopheles* around Fort Crook so that control measures were placed in operation. Their survey in the vicinity of the Alliance Air Base resulted in the city of Alliance carrying on a program to control the pest mosquitoes.

After the war years, mosquito control and interest in mosquitoes again went into a decline. Dr. Tate left the State to take another position and the interest in mosquito control at the College of Agriculture rapidly disappeared. However, during this same period, many cities and villages in the State of Nebraska had young men returning from military service and they had seen how the military services were able to bring about mosquito control or at least, temporary relief from mosquitoes. These young men were able to sell local governing bodies the idea of some type of mosquito control program. Most of these mosquito programs were rather superficial and they consisted mostly of the town purchasing a sprayer or some type of fogging machine and running up and down the streets two or three nights per month.

In the latter part of 1940, the United States Public Health Service became interested in several mosquito problems in Nebraska. Most of their interest derived from the building of large dams for the impoundment of water for irrigation purposes or for flood control purposes, with the result that several entomologists of the United States Public Health Service were detailed to Nebraska to make surveys in various river basins so that they could make recommendations to federal agencies building these dams. Mr. George A. Thompson was one of the first entomologists of the Public Health Service to work in Nebraska. Mr. George Keener also did some of the early work in Nebraska. This material was summarized in various publications of the Public Health Service. Around 1950, the Public Health Service became interested in irrigation and its relationship to water management, and a laboratory was established at Mitchell, Nebraska. In early 1954, it was discontinued, and its personnel was moved to Logan, Utah. This laboratory started many projects, some of which were left uncompleted. Most of

the work was related to the problems associated with irrigation. They were able to show that the most serious mosquito breeding areas in the grass lands were the seepage areas along the large irrigation ditches and the practice of flooding pastures. In addition, some basic biological studies on grass-land mosquitoes were made. The workers at this laboratory collected large live samples of *Culex tarsalis* and were able to show that the virus of western equine encephalitis is present in the mosquitoes found throughout the North Platte valley.

In 1952, the author was hired by the Nebraska State Department of Health. Among the duties assigned to him were studies in vector control. Unfortunately, only a small portion of his time can be devoted to mosquito control, but several surveys have been made, and still others are in operation.

To sum up the mosquito problem as it exists in Nebraska at the present time, the problem must first be related to a specific section of the State. The most serious mosquito problems existing are in the irrigated lands of the western portion of the State. The number one problem area is the North Platte valley, from the head waters of Lake C. W. McConaughy to the Wyoming line. This is a large irrigated area. All the irrigation is by ditches. Throughout this area are many large seepages, and the practice of pasture is widespread. This area has a well-known history of encephalitis.

The number two area would probably be the Republican valley in the southern part of the State. This is also an irrigated area. However, it is just starting its importance as an irrigated area with the completion of a large dam near Trenton by the Bureau of Reclamation. This area is of great interest at the present time, because in 1954, we had over twenty-two cases of encephalitis reported from Red Willow County, Nebraska. There are also other areas throughout the State where mosquitoes are a local problem. The Missouri valley has a large population of mosquitoes from the Kansas line to the South Dakota line. However, most of these mosquitoes are strictly pest mosquitoes and are not concerned in disease transmission. In other areas of the State, there are smaller irrigation districts. Some are in good condition, while others are in poor condition and present mosquito breeding problems.

Another area where we have done a limited amount of work is in the oil producing areas of the State. Two years ago, a study was conducted in Richardson County, Nebraska, which has the oldest oil fields in Nebraska. All the oil fields in Richardson County produce large quantities of salt water as well as oil. The salt water is separated by chemical means and placed in ponds. Some of these ponds have become fairly large and have shorelines with emerging vegetation which produce large numbers of mosquitoes. So far, we have not found any of the typical salt-marsh mosquitoes coming into these areas, although they do have fairly high salt content. We are in the process of finishing a study on this subject and hope to have it published within the next year. Some of the largest wet land areas of Nebraska lie in the Sand Hills area of Nebraska, where mosquito production is very high. However, since this area has an extremely low human population, mosquitoes have never become a problem, at least as far as man is concerned, although they do have a minor effect upon beef cattle.

Now let us take a look into the future as far as mosquito control in Nebraska is concerned. Studies by the Nebraska State Department of Health seem to indicate that human cases of encephalitis are on the upswing. It is rather difficult to determine whether or not we actually have more cases of encephalitis than we had ten or fifteen years ago, because it is well known that many cases of encephalitis were diagnosed as polio or some other disease. With the new Salk vaccine, this picture will probably change, and we may arrive at a more accurate picture. The knowledge that encephalitis is a mosquito-borne disease is becoming more widespread

throughout the State, and people are beginning to realize that the only satisfactory control of encephalitis is through mosquito control. Also, they are learning that mosquitoes can be controlled. As in many other areas, one handicap that has faced mosquito control in Nebraska is the widespread idea expressed in the words, "mosquitoes were here when my grandfather was here, and they are going to be here in my children's day." This need not be true, for it is possible to bring about satisfactory mosquito control and eventual eradication of the mosquito from many populated areas of the State. We already have an active group in the North Platte valley, who are attempting to interest their neighbors in a mosquito abatement district bill, and it is my understanding that this group will have their local representative at the Nebraska Unicameral present such a bill to the 1957 Legislature. In addition, more and more towns are becoming conscious of the fact that satisfactory mosquito control can be done. Although at the present time, most towns and villages feel that they do not have the right to carry their control measures beyond corporate limits, many of them are also realizing that it is impossible to control mosquitoes simply by running a sprayer or fogger up and down the streets and alleys of a given village or town. Therefore, they are going outside the limits of the city and attempting to do some work. However, this type of program is best handled through a mosquito abatement district, rather than by a single municipality attempting to put on a control program. It is my personal feeling that an educational program of the State Department of Health can eventually explain to the citizens the objective of mosquito abatement districts, and how they can make living a little more healthful and pleasant in any given area. Through this, we hope eventually to have mosquito abatement districts in many of the major valleys of Nebraska's rivers. Although the history of mosquitoes and mosquito control in Nebraska is short, we have gone a long way in a short time, and in the coming years we hope to be among the leaders in mosquito control in this country.

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IRRIGATION EFFICIENCY AND MOSQUITO PRODUCTION [1]

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The association of mosquito problems with agricultural irrigation is not new. George E. Waring, Jr., in his book "Sewerage and Land Drainage," published in 1889, referred as follows to a paper written in 1870 by the French worker Leon Colin: "Colin also states that irrigation causes an increase of intermittent fever (malaria)." Waring goes on to say, "Similar observations are made in California and in our dry Western plains, many portions of which are malarious under all conditions, with a sudden and great aggravation on the introduction of irrigation." At the time Waring wrote his book the cause of malaria was not known. We now know that he and Colin were actually reporting an increase in mosquito populations caused by the practice of irrigation. Recent studies have shown that faulty agricultural practices are the primary cause of mosquito problems in many areas.

Irrigated acreage, and therefore the potential for irrigation-caused mosquito problems is continually increasing throughout the United States. Prior to 1950 most of the irrigated acreage in the United States was in the 17 Western States. The 1950 Census of Agriculture reported a total of 25,787,455 acres of irrigated land. About 94 percent of this was in the 17 Western States, 5.3 percent in Arkansas, Louisiana and Florida, and only 0.6 of one percent in the other 28 States. If present trends continue, about 4,600,000 additional acres of land in arid and semi-arid areas will be irrigated by 1975. Supplemental irrigation is rapidly gaining favor in humid and semi-humid areas. Although the largest acreage increases in irrigated land occurred in Texas and California during the ten-year period from 1939 to 1949, the largest proportionate or percentage increases occurred in the humid area states of Massachusetts, Oklahoma, and Michigan. Several millions of acres of land have been placed under supplemental irrigation since the 1950 census. If present trends continue, a minimum of 8,700,000 additional acres of land may receive supplemental irrigation by 1975. A major portion of the increase will occur in States which have previously reported small totals of irrigated acreage. Although mosquito problems associated with supplemental irrigation may sometimes not be as severe as those associated with full irrigation, they are always important to a mosquito control program. It appears, therefore, that the factors associated with irrigation—caused mosquito problems may soon be of concern to public health and mosquito control agencies throughout all of these United States.

Efficient use of water resources is a matter of national concern. Good irrigation and water management practices, which aim toward efficient use of irrigation water, drastically reduce or eliminate many irrigation-caused mosquito problems by reducing the extent and duration of ponded water areas suitable for mosquito production. The best attack on a majority of irrigation-caused mosquito problems appears to be the promotion of practices which increase efficiency in the use of irrigation water. It behooves us, then, to be familiar with irrigation efficiency and to know what it is.

The efficiency of any given operation can be generally defined as the percentage ratio between results actually achieved and the theoretical maximum results obtainable. Efficiencies commonly referred to in irrigation practice relate to quantitative measurements of water and soil moisture. The quantitative efficiencies we are most interested in are conveyance and delivery

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efficiency, farmstead irrigation efficiency, and field application efficiency.

Conveyance and delivery efficiency can be defined as the percentage ratio between the quantity of water actually delivered to the individual farms and the quantity of water turned into the upper end of the conveyance system from the original water source. Factors which reduce this efficiency are seepage losses from the canals and structures, evaporation, transpiration from weeds growing in the canals, water wasted due to the diversion of more water than the farmers use, and water wasted due to accidents.

Farmstead irrigation efficiency can be defined as the percentage ratio between the quantity of water stored in the soil in the plant root zone and the quantity of water delivered to the farm. Factors which reduce this efficiency are seepage losses from farmstead ditches and structures, evaporation, transpiration by non-beneficial plants, accidents, and poor field application practices.

Field application efficiency can be defined as the percentage ratio between the quantity of water stored in the soil in the plant root zone and the quantity of water applied to the field. Factors which reduce this efficiency are deep percolation losses due to the application of excess water which percolates downward through the soil to a position below the plant root zone, evaporation from water standing on the soil surface, and waste water which runs off the lower end of the irrigated field.

Quantitative irrigation efficiencies, as defined above, affect both off-field mosquito production, or mosquito production outside the irrigated fields, and production on the field. Off-field production occurs through such situations as flooded roadside ditches, canal borrow pits containing water seeping from the canals, water standing in poorly constructed or poorly maintained farmstead ditches, and the development of seepage areas on the lower lands of an irrigation project. These problems can be attacked from an agricultural standpoint on the basis of saving water, preventing the development of high water table and effluent seepage drainage problems, or saving time and labor through the use of well designed and properly maintained irrigation facilities.

On-field mosquito production, or mosquito production within the irrigated fields occurs through ponding of water in the field, poor leveling with low spots, lack of surface outlets or excessive and prolonged applications of water. Practices which increase field application efficiencies also decrease mosquito production. This has been shown for intermittent irrigation by a cooperative investigation in California by the California State Bureau of Vector Control, the California Mosquito Control Association, and the Agricultural Research Service. (Davis and Husbands, 1955, and MacGillivray and Husbands, 1956). There are some exceptions to this rule, however, because application efficiencies are based on average measurements for the fields concerned and do not consider the time factor. We need to do much more work to permit us to explain and to predict these exceptions. We need to initiate studies to define the relationship between mosquito production and water application efficiencies for continuously flooded crops such as rice.

Although irrigation efficiencies generally do not consider the time factor, agricultural technicians are concerned with the length of time water is applied to the surface of the soil in intermittently irrigated fields. Intake opportunity measurements are often made in connection with application efficiency measurements. Intake opportunity represents the length of time water stands on, or is applied to, the various areas of an irrigated field and indicates the opportunity for water to soak into those areas. The purpose of such measurements is to determine the equality of distribution of irrigation water within the field. It should be mentioned that no method of irrigation provides perfect distribution of irrigation water, and that ponding of water on the soil surface can, and frequently does, occur even when

sprinkling methods are used. Although, to my knowledge, intake opportunity measurements have not been so expressed, they could be converted to a "distribution efficiency" which would compare distribution actually obtained to the perfect distribution which is theoretically possible. Such a distribution efficiency would relate directly to the length of time water stands upon the soil surface in intermittently irrigated fields and so could be related to the opportunity for mosquito production within those fields. We have a serious need for the development of expressions, such as distribution efficiency, which will permit us to make direct comparisons between mosquito production and the efficiency of irrigation and water use practices. Such terms must obviously be accepted by, and useful to, irrigation and water use technicians.

Human nature being what it is, the correction of some irrigation-caused mosquito problems will have to be obtained through the enforcement of laws pertaining to public health, public safety, and public nuisances. Law enforcement is not ordinarily a popular way of doing business and is usually quite difficult. Some irrigation-caused mosquito problems can be corrected through the desire of some agencies, such as irrigation districts or county road departments, for good public relations. This approach does not always work, however, as we all know. The easiest and best approach, in the long run, will be to prove that efficient irrigation and water use practices not only reduce mosquito production but save water and increase crop production. We will then be in the excellent position of being able to show that the practices which should be adopted for mosquito control are the same practices which should be adopted for improved water use and crop production. A good start in that direction has been made through a project now under way in Montana. In 1955, co-operative field studies were initiated in the Milk River Valley, Montana by the U. S. Public Health Service and the Agricultural Research Service. The objective is to determine whether or not improved fertilization and irrigation practices can be developed which will increase bluejoint (*Agropyron smithii*) yields on heavy Bowdoin clay soils and at the same time decrease mosquito production. Preliminary results indicate that a five-fold increase in bluejoint yields is possible by using nitrogen fertilizer and allowing 60 percent of the available moisture within the root zone to deplete prior to irrigation. Mosquito production under these conditions was eliminated, whereas adjacent flooded border strips representing former irrigation practices in the area produced an abundance of *Aedes* and *Culex tarsalis* mosquitoes.

We should remember that when we work to correct irrigation practices which cause mosquito problems we are dealing with the bread and butter operations of the irrigation farmer. Our corrective programs must be based on facts, not deductive reasoning. The research we do to collect the needed facts must be based on sound scientific principles and must consider all aspects of the problems we are investigating. Physiological and ecological investigations of the mosquitoes concerned should be correlated with investigations of the plants involved, the associated soil and water phenomena, and the associated management practices. Good correlation will in many cases require concurrent measurements on the same study sites. Measurements should be made by qualified personnel whose competence will not be questioned. Entomological aspects of the problems should be investigated by qualified entomologists. Agronomic aspects should be investigated by qualified agronomists. Soil and water aspects should be investigated by qualified soil scientists and irrigation engineers. Since most individual research groups do not have personnel qualified to conduct investigations in all the fields of entomology, agronomy, and soil and water management, the best hope for reasonable progress appears to be a co-operative pooling of knowledge, resources and personnel in joint research projects. We have made a good start in

this direction, but we have only scratched the surface of the potential progress which can be made through an expanded program of co-operative effort.

Mosquito control and public health agencies are most certainly not alone in their desire to promote more efficient irrigation and water use practices. Agricultural agencies, such as State Extension Services and the Federal Soil Conservation Service, have for many years been conducting programs aimed at improved irrigation and water use practices, but agricultural benefits alone have frequently not provided arguments strong enough to obtain immediate adoption of such practices. Mosquito control benefits, including improved public health and comfort and economic gains from improved farm animal health and comfort, can be of great assistance to such programs. As technical information is developed to prove the existence of these benefits the agricultural agencies will welcome it and will use it. The day will come when it will be common practice for agricultural and water use agencies to use mosquitoes as symptoms of improper or inefficient water management and irrigation practices. How soon that day arrives depends upon our progress in obtaining the information those agencies need.

The relationship between mosquito production and the efficiency of irrigation and water use practices offers us the opportunity to develop a powerful weapon for use in combatting irrigation-caused mosquito problems. This opportunity is not in itself, however, an answer to our problems. We will obtain the answers we need only through intelligent planning, wholehearted cooperation, and hard work.

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THE TOLEDO SEMINAR PROCEEDINGS

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ARTICLES

A SURVEY OF INSECTICIDES USED IN COUNTRY-WIDE MOSQUITO CONTROL IN 1955 *

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The objectives of this brief résumé of a country-wide survey on chemicals regularly employed in mosquito control and of those experimentally tested during 1955, were to assemble up-to-date information on the extent to which the newer insecticides are now used; their efficiency in pest-mosquito extermination in comparison with the older insecticides; and present trends in mosquito control agencies.

In January 1956, a questionnaire was sent to most mosquito control agencies in the United States and Canada. By March 1, 1956, replies from some 120 active mosquito control commissions in 35 states had been received. After a careful study of the reports, the information was classified as follows:

1. Principal insecticides employed for practical mosquito control.
2. New insecticides tested or used in small quantities on specific areas.
3. Mosquito resistance to DDT.
4. Future trends in mosquito control.

RESULTS

INSECTICIDES EMPLOYED (1 and 2). The principal toxicants employed by most of the mosquito control districts were DDT and mosquito-oil, but substantial quantities of BHC, malathion, pyrethrum, and dieldrin were also used, particularly in areas where there was mosquito resistance to DDT. Small quantities of other new insecticides were also applied, either experimentally or on specific areas. In some districts only one insecticide was mainly used, while in others, several toxicants, singly or combined, were applied. Data on frequency of the use of various insecticides show that *DDT,* in various formulations, was used by 91 agencies; *oil alone,* with no other toxicant added, by 31; *Pyrethrum,* either as emulsion or added to DDT-oil solution, by 23; *malathion* by 11; *BHC* by 5; *dieldrin,* as emulsion and granular dust, by 6; *Lethane or thanite,* added to DDT-oil, by 10; *chlordane* by 4; *heptachlor* by 4; *parathion* by 2; *toxaphene* by 2; *DDD* by 2; *aldrin* by 1; *Paris green* by 1; and *EPN* by 1. *Parathion* was applied by 8 districts in California where extra precautions were practiced for the prevention of possible health hazards.

Pre-Breeding. Thirty-one districts practiced pre-breeding treatments; 23 applied DDT and reported results of fair to excellent, with one application, applied in the early season, remaining effective for from 2 months to the better part of the summer.

MOSQUITO RESISTANCE TO DDT AND OTHER CHLORINATED INSECTICIDES (3). Eleven agencies reported definite resistance to DDT, either over all the county or in local areas. A number of districts substantiated previous observations that DDT is less effective on mosquito larvae during hot weather than during cool weather, and less effective on certain polluted waters.

FUTURE TRENDS IN MOSQUITO CONTROL (4). Reports definitely indicate greater

* Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Entomology, New Brunswick.

emphasis on permanent control methods and less on larvicides and adulticides. This is indeed an encouraging trend. From years of experience in mosquito extermination, we have learned that the most effective and lasting results are obtained by permanent control operations, usually accomplished by proper water management. Only where permanent methods are either impossible or impractical does control resort to the use of chemicals.

Another highly desirable trend shown by the reports is the tendency among most agencies to eliminate the use of highly poisonous chemicals and thus minimize possible hazards to the health of mosquito control operators and the public.

The writer wishes to take this opportunity to express his gratitude to all the participants in the survey and to Ted Raley, our Secretary of the A.M.C.A., for supplying the mailing list of all the U.S.A. mosquito control agencies.

NOTES ON SOME FRESHWATER *AEDES* MOSQUITOES IN MARYLAND *

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In the metropolitan areas of Prince George's and Montgomery Counties, Maryland during recent years *Aedes vexans* (Meig.) has been the most important mosquito from the standpoint of annoyance to man. *A. canadensis* (Theob.) is also a noteworthy pest, and occasionally *A. trivittatus* (Coq.) constitutes a nuisance. Observations on the bionomics of these species with emphasis on seasonal distribution are reported here.

In the College Park area larvae of *Aedes canadensis* can be found in late February but they are not abundant until April. In 1953, 1954, and 1955 examinations of numerous breeding places showed that the peak of the larval population was reached during the second week in April. The greatest number of pupae are seen from mid-April to mid-June. Adults are active beginning about May 15 although biting records have been obtained as early as May 1. *A. canadensis* is followed by *A. vexans* in the spring, very often in the same breeding places. Our earliest record for *A. vexans* larvae is March 20. Maximum numbers of pupae appear about June 1. Pupation in the spring appears to take place during a short period of time, unlike pupation of *A. canadensis* which extends throughout many weeks. Biting records of *A. vexans* begin on May 16, but adult activity is greatest during the first two weeks of June. It is at this time that mosquito annoyance is severe in the College Park area because in addition to large numbers of *A. vexans,* many *A. canadensis* females are biting.

Examinations of suitable breeding places at six locations were made each week from March 17 through October 25, 1955. During June and July larvae disappeared, and in most cases the breeding places dried up completely. The last of the early larvae of *A. vexans* were taken on June 30; then about the middle of August they were found at four of the six locations. These larvae matured rapidly. Adults were ac-

* Misc. Publication No. 254, Contribution No. 2670 of the Maryland Agricultural Experiment Station, Department of Entomology (Project H-59).

tive from the last of August until the first of October. It is our opinion that two generations of *A. vexans* were produced in 1955, but there is no proof that larvae found in August hatched from eggs deposited in the same year. It is possible that the August population resulted from a delayed hatching of eggs. Headlee (1945) reported repeated hatchings extending into the third year after eggs were brought into the insectary.

At the six locations mentioned previously, larvae of *Aedes canadensis* disappeared after May 12. Later at one of the locations they were collected only once, on August 22. Horsfall (1955) reported that eggs of this species hatch in the fall in New Jersey and Illinois. It appears that eggs which hatch in August are the progeny of adults which emerge in May or June, but this has never been proved by actual experiments.

On May 12, 1953 mosquitoes were reported in annoying numbers in a small subdivision near Kensington. A light trap was operated from May 15 to July 15 and on June 1 one female *Aedes trivittatus* was collected. Six specimens were trapped through June 9, but none thereafter. On June 4 vast swarms of *A. trivittatus* were biting viciously in the daytime, and in this case it appeared that the New Jersey type light trap was not a reliable index of the abundance of this species. During the last of May and first part of June 1953 *A. trivittatus* was the only species that reached pest proportions in the Kensington area. In College Park a few biting collections were made during the same period, but *A. trivittatus* was greatly outnumbered by *A. canadensis* and *A. vexans*. An intensive search for larvae on June 4, 1953 was unsuccessful. In 1954 concentrated efforts to find larvae at Kensington were made on April 28, May 5, May 13, and May 22. No larvae of *A. trivittatus* were located, and adults did not constitute a nuisance in that year. Careful studies in 1955 indicated that this species had almost disappeared from the area where the adults were so abundant in 1953. One adult was collected on August 29. The decrease in numbers was attributed to a considerable amount of grading and filling.

Some dipping was done in 1954 in College Park in several places which appeared to be suitable habitats for *Aedes trivittatus* larvae, and these spots were checked carefully during 1955. Only one larva was found. It was taken from a small temporary pool on April 28. The shallow pool contained water in which *A. canadensis* larvae were abundant from March 17 to April 21, but it dried up completely on April 22. A few days later the area was flooded with rain water. The single third instar larva of *A. trivittatus* had apparently developed rapidly, a known characteristic of the species (Abdel-Malek, 1948). *A. trivittatus* was not a pest in College Park in 1955, but adults were collected attempting to bite on five occasions from August 29 to October 7.

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CULEX (CULEX) AFRIDII SP. N. A NEW SPECIES OF MOSQUITO (DIPTERA, CULICIDAE) FROM DACCA, EAST PAKISTAN

M. QUTUBUDDIN *

This species belongs to the *Lasioconops* or *sitiens* group (Edwards, 1932) of the subgenus *Culex* which is distinguished by the presence of a pale band on the proboscis and by the banded tarsi.

It is a rather large dark brown species with a purplish blue sheen on thorax, abdomen and legs. It is clearly distinguished from its closest ally *C. bitaeniorhynchus* Giles by its very dark brown color, the basal pale abdominal bands and the tarsal rings not involving the apices. The hypopygial characters are so distinctive that it cannot be confused with any other species of the genus.

Description of holotype ♂. *Head:* Vertex and nape densely covered with dark brown upright scales. The ends of the scales are markedly expanded. A patch of broad creamy white scales low down at each side touching eyes.

A row of strong somewhat dark brown bristles in front of the erect upright scales along the eye-margins converging towards the nape.

Proboscis: (Half of it broken in the single male described). Dark brown with a broad pale band in the middle. Underside brown, upperside with a narrow pale longitudinal stripe continuous backwards from the pale band. Palps missing. *Antennae* (one missing), tori dark brown; flagellum bushy with dark brown hairs.

Thorax: Integument of anterior pronotum, posterior pronotum and mesonotum very dark brown with a purplish blue sheen. Scutellum and the posterior margin of mesonotum pale brown. Anterior pronotum covered with a mixture of golden and very dark brown narrow scales and dark brown bristles, the latter on the upper margin. Anterior half of mesonotum mainly covered with narrow golden scales interspersed in the middle by very dark brown scales; posterior half up to scutellum and wing roots also covered with similar narrow dark brown scales. Base of middle, apex and lateral lobes covered with very dark brown scales. All the three lobes with long dark brown bristles. Postnotum light brown. Integument of pleura dark brown except that of mes-epimeron which is pale. Meron also dark. Pleura devoid of scales except two small patches of white scales on the sternopleura, one on the upper portion and the other on the posterior lower margin. Color of integument under the upper patch of scales pale. Lower mesepimeral bristle absent Coxae dark except the hind one which is pale.

Wings; about 5 mm. Mainly dark, veins covered with narrow and broad black and broad dull creamy scales as follows: Costa covered with black broad scales, sub-costa with broad black and dull creamy scales; second vein with mostly dark narrow scales. Rest of the veins covered with mostly narrow black scales with a sprinkling here and there of broad black scales. *Legs:* Dark brown much darker than in *C. bitaeniorhynchus* Giles with numerous scattered pale scales giving a speckled appearance when viewed from certain angles. Femora, tibiae dark, mid and hind femora pale beneath. Tarsi dark with only basal pale rings. *Abdomen:* Tergites very dark brown with a purplish blue sheen and with narrow basal yellow bands.

Male Terminalia. Style: (fig. 1, A.*s*) Short about 1/5 the length of the coxite, curved with its membranous flange, it very closely resembles the head of a cobra, the flange representing the dilated hood of the snake. The terminal appendage is short. Coxite almost three and half times its

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greatest width, completely devoid of scales covered with short hairs on the dorsal side and with some thin long hairs on the outer side along the distal border. The presence of a single very long strong hair on the outer border of one of the coxites and the prominent scars of fallen hairs along the border of both the coxites indicates the existence of similar long strong hairs on the outside, that appear to have been rubbed off in the single specimen described. The ventral side covered with fairly numerous fine hairs and there is a row of short fine hairs on inner sternal area below the lobe.

Subapical lobe of coxite bears one leaflet and 3 rod-like bristles, one of which is longer than the other two. Basal lobe divided, the upper portion having two leaflets one of which is large and broad the other one shorter and narrower; and three pale rods, stout and curved at tip,

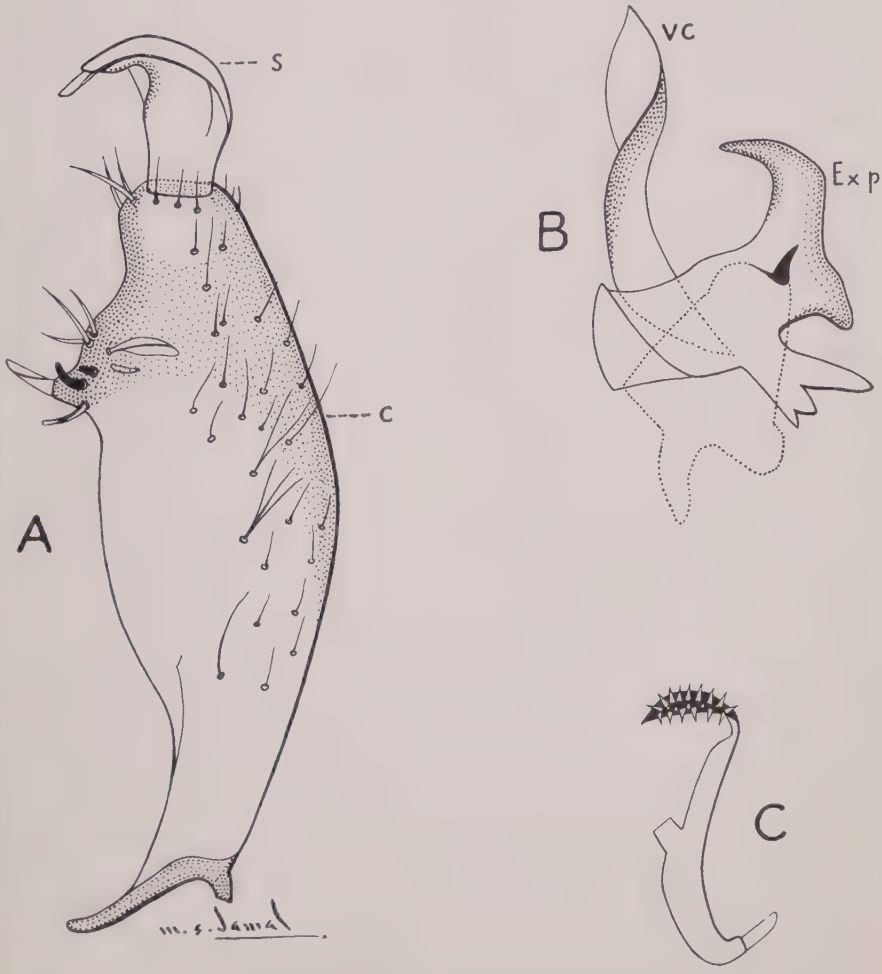

Figure 1. *Culex* (*Culex*) *afridii* sp. n. Male terminalia. A-Side piece, B-Phallosome, C-paraproct; s, style, c coxite; vc, ventral cornu; Ex p., external process.

one of which is shorter than the other two. Lower portion bearing two leaflets one of which is sinuous with a broad stem occurring on a highly sclerotised raised tubercle; the other leaflet is shorter and narrower. At the base of the tubercle arise two dark short stout rods curved at tip, one of which is much smaller than the other. *Phallosome:* The phallosomal chitinisations (fig. 1, B) comprise a highly complex structure. Lateral plate with a very highly sclerotised and large ventral cornu terminating distally in an expanded and spatulate fold. The ventral cornu of the two sides fused together by a dorsal and ventral chitinisation extending from the base up to the point of folding. The external process is also a highly chitinised, remarkably sickle-shaped structure directed medially. The median process bears four blunt teeth, one of which is very large and thumb-like. It is sinuous and folded. The basal plate which is well-developed has two fingerlike arms. Paraproct with a crown of short spines and a narrow pointed basal arm with an abrupt elbow-like bend.

Described from a single type male collected by the author from Dacca, East Pakistan, in October, 1952. The holotype male and one set of male terminalia of the same specimen are being deposited in the British Museum.

I have great pleasure in dedicating this species to Col. M. K. Afridi, M.D., Ch.B., D.T.M. & H, IMS., under whose inspirational leadership in the field of research on mosquitoes, malaria and other insect-borne diseases, I re-started my career after migration to Pakistan.

ACKNOWLEDGEMENTS

I take this opportunity to tender my grateful thanks to Dr. Salimuzzaman Siddiqui, Director, Pakistan Council of Scientific and Industrial Research, for the permission to publish this paper.

My thanks are also due to Mr. M. S. Jamal of the Zoological Survey Department, Karachi, for the camera lucida drawings.

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SEASONAL HISTORY OF *CULEX TARSALIS* AND ASSOCIATED SPECIES IN LARVAL HABITATS OF THE TENNESSEE VALLEY REGION

W. E. SNOW and EUGENE PICKARD *

Observations on the seasonal occurrence of mosquitoes in the Tennessee Valley region indicate that *Culex tarsalis* Coq. has been found only in the fall of the year. Although it has never been found in abundance, its density and distribution vary from year to year. Based on U. S. Army light trap and adult resting station records, Carpenter (1945) recorded *C. tarsalis* only at Camp Tyson near Paris, Tennessee, in 1942, whereas they were found at various army installations in Alabama, Georgia, Kentucky, Mississippi, and Tennessee in 1943 though not at Camp Tyson. In 1944, adults were reported at one or more installations in the aforementioned states including Camp Tyson, Tennessee. Collections in adult resting stations on Kentucky Reservoir used in connection with the TVA malaria control program showed *C. tarsalis* widespread in September 1953 but represented only by a single collection in 1954.

Light trap collections by TVA in 1953 indicated that *C. tarsalis* was present during September in the main reservoir system extending through western Tennessee, northern Alabama, and east Tennessee between Chattanooga and Knoxville. One light trap in the floodplain of the French Broad River flowing through the foothills of the Smoky Mountains was negative for *C. tarsalis* in 1953, 1954, and the spring of 1955. Records of light trap catches from a trap at Hustburg, Tennessee, where Duck River broadly joins the Tennessee River, indicated a high of 67 females and 4 males on September 15, 1953, with 7 additional specimens captured in the ensuing two weeks. At Dayton, Tennessee, across the Cumberland Mountains from Hustburg, 6 female *C. tarsalis* were captured on September 14 and 16, 1953, collectively.

With the exception of one larval series in the Authority's collection from flooded hoofprints near Leighton, Alabama, by Pratt and Quinby in October 1944, no information has been available on the type of larval habitats used by *C. tarsalis* in the Tennessee Valley basin states. Because of its general connection with encephalitis and the increased interest in irrigation crops and pastures in the Tennessee Valley, efforts were made to determine the habitat type and larval associations of *C. tarsalis* as part of a two-year survey on insects of public health importance associated with TVA reservoirs. The results reported in this paper cover limited observations during three growing seasons, 1953–1955, although the larval habitats discussed were not found until the fall of 1954 or later.

Habitats in Tennessee. One of the areas selected for investigation was about the grounds of former Camp Tyson near Paris, Tennessee. Following the war, the camp site was acquired by a private company for the production of industrial clays. Most of the acreage, however, has been turned into pasture for livestock and quarter horses. Two of the breeding areas were associated with the old water system of the camp. The third was a grassy roadside ditch intermittently flooded by normal rainfall.

The first site, designated as the fireplug seep area, was a very shallow roadside drain thickly populated with millet, *Echinochloa crusgalli* (L.) Beauv.; fantail *Setaria geniculata* (Lam.) Beauv.; Bermuda grass, *Cynodon dactylon* (L.) Pers.; and with occasional panic grass, *Panicum dichotomiflorum* Michx., and smartweed, *Polygonum pennsylvanicum* L. When first visited on September 9, 1954, a large series of *Psoro-*

* Malaria Control Branch, Division of Health and Safety, Tennessee Valley Authority, Wilson Dam, Alabama. Submitted December 1955.

phora spp. were observed emerging, mainly *P. confinnis* (L. & A.) and *P. cyanescens* (Coq.), while mature larvae and pupae of *P. discolor* (Coq.) and *P. ciliata* (Fab.) were also collected. Rain in the early part of September caused excessive flooding of the area and the subsequent hatch of *Psorophora*. On September 22, larvae of *Culex tarsalis* were collected without associated species. By October 27, *C. tarsalis* was no longer found here, but *C. restuans* Theob. and *Anopheles punctipennis* (Say) had appeared. One species of moth fly, *Telmatoscopus furcatus* (Kin.) was reared from the seep in December, but mosquitoes were not found until February 24, 1955, when small larvae of *Culiseta inornata* (Will.) were seen beneath a thin layer of ice. At this time a large number of midge pupae, *Anatopynia guttularis* (Coq.) were present. In March, larvae of *Aedes vexans* (Meig.) and a midge, *Anatopynia dyari* (Coq.), appeared. Rains in mid-April hatched larvae of typical grassland *Psorophora* such as *P. confinnis, P. cyanescens,* and *P. ciliata* along with another series of *A. vexans* and a single representative of a typical salt-marsh species, *Aedes sollicitans* (Walk.). Of the several hundred larvae returned to the laboratory for rearing nearly all were *P. confinnis*. It was surmised that perhaps salt blocks left on the ground for livestock or perhaps dust from mined clay might have made conditions favorable for the development of *A. sollicitans*. Repair of the leak at the hydrant caused the site to go dry in the summer of 1955, although heavy rains late in July hatched a brood of *P. discolor, P. ciliata, P. confinnis,* and *P. cyanescens,* and in September, *P. ciliata* and *P. confinnis*. In neither case were larvae able to complete deevlopment before the pool went dry. Since the water table at this site was not replenished during the summer by seepage from the hydrant, fall rains in October and November were insufficient to maintain an aquatic habitat when *C. tarsalis* was expected to invade the situation as it did in 1954.

The second site, called a ditch (fig. 1), was a grass-lined roadside ditch whose lower end was more or less blocked by a secondary gravel road which permitted retention of water in the ditch for at least a month after heavy rains. No other source of water was provided. Marginal grasses were millet, fantail, and Bermuda grass, while emergent plants were panic grass, smartweed, and several clumps of *Juncus effusus*. The panic grass (*P. dichotomiflorum*) volunteered after the ditch went temporarily dry in August and September 1955. The ditch was first visited on September 9, 1954, when a large brood of *Psorophora confinnis* and *P. cyanescens* was emerging. Larvae of these floodwater species and adult *P. discolor, P. ciliata,* and *A. vexans* were also collected, but no *Culex* were found. When the ditch was again visited on October 5, larvae of *Culex tarsalis* (1), *C. pipiens* L. (7), and *P. confinnis* (8) were present in small numbers. Later collections on October 27 yielded *C. pipiens, Anopheles punctipennis,* and *A. quadrimaculatus* Say, but no *C. tarsalis* were seen. By December, only *A. punctipennis* and *Culiseta inornata* persisted. In March 1955, larvae of *A. vexans* and *C. inornata* were found. During May and most of June the ditch was dry. Light rains in July were sufficient to maintain productivity of *Culex erraticus* (D. & K.) and *A. quadrimaculatus* and occasional *Psorophora*. Pupae of *Culicoides crepuscularis* Mall., *C. haematopotus* Mall., and

FIGURE 1. An intermittently flooded ditch at former Camp Tyson, Tennessee, where broods of *Culex tarsalis* were found in the fall of 1954 and 1955.

Dasyhelea grisea (Coq.) were found among the bases of emergent *Juncus* on July 7. The ditch was dry most of August and September. The ditch was flooded heavily in October, larvae of *P. confinnis, P. ciliata, P. cyanescens,* and *P. discolor* being observed on October 5, 1955. By October 11, *A. punctipennis* and *Culex salinarius* Coq. had shown up. Predominance of *Culex* was evident at the October 19 inspection when *C. pipiens* (90), *C. salinarius* (11), *C. tarsalis* (4), and *C. territans* Walk. (3) were represented (50 dips) along with *A. punctipennis,* a few straggling *P. ciliata,* and two larvae of *C. inornata.* On November 1 and 15, the same species of *Culex* were still present as in October and in addition *C. restuans* appeared. Of the 166 larvae and pupae reared in the November collections, the culicine species were as follows: *C. pipiens* (97), *C. salinarius* (22), *C. inornata* (21), *C. tarsalis* (13), *C. territans* (12), and *C. restuans* (1). Larvae of *C. inornata* were observed in abundance on November 15. Of the anophelines, *A. punctipennis* continued breeding heavily in November and *A. quadrimaculatus* was taken in small numbers on November 1 and 15. A final inspection on December 9, 1955, revealed larvae and one pupa of *C. inornata* in marginal grass beneath 1/4" of ice.

A third breeding site at Camp Tyson known as the seep (fig. 2) was not discovered until the latter part of May 1955. It consisted of about 100 feet of grassy roadside ditch which had been continually wetted for some time by water seeping from a surface outlet of the local water system. Beds of mud plantain (*Heteranthera reinformis* R. & P.), a plant somewhat similar to watercress in appearance and growth habit, were well established in the ditch where the seep water was entering. Farther down the ditch the bottom had become heavily colonized by panic grass (*P. dichotomiflorum*) and *Paspalum* sp. The depth of the water ranged from 3–4" over the bottom of the ditch. In the panic grass area where vegetation greatly retarded water flow, a rather thick rust-colored layer of flocculent organic matter was present. This medium appeared to be particularly favorable for the production of *C. salinarius* affording it protection from excessive surface temperature and predators.

Figure 2. Beds of mud plantain in a seep at former Camp Tyson, Tennessee, where *Culex tarsalis* was found breeding in the fall of 1955.

At the time of the initial inspection on May 18, only larvae of *C. restuans* were found. In June, July, and August, the predominant anopheline was *A. punctipennis,* the principal culicine, *C. salinarius,* and the only floodwater species, *P. confinnis.* The larvae of *P. confinnis* were associated with hoofprints near the issuance of seep water and were incidentally the only *Psorophora* species ever taken in this seep area. This hoofprint area was generally populated with millet. The collections of June 24 and July 7 and 13 revealed the presence of a punkie, *Culicoides variipennis* (Coq.), which becomes very abundant in brackish water in the western states and has also been recently collected in enormous numbers from brackish water at Saltville, Virginia. Pupae of this punkie were collected both in the *Heteranthera* and *Panicum* areas of the seep, and adults were swept from marginal fantail and Bermuda grass during the day. The pupae ranged from 1–3 per dip in vegetation. Other heleids appearing in summer collections included *Bezzia glabra* (Coq.) on June 24, *Dasyhelea grisea* on July 7 and 13, and *Bezzia setulosa* (Lw.) on July 13.

In July and August, *C. pipiens* also appeared but was never numerous compared to *C. salinarius*. Larvae of *A. quadrimaculatus* did not invade the seep until September and were still present until October 5 but not thereafter. Two heleids, *Culicoides crepuscularis* and *Stilobezzia coquilletti* K., were taken on September 2. The pupae of *C. crepuscularis* were very frequent and were taken principally in the shallow flooded panic grass area. Large numbers of tendipedid larvae (5+ per dip) in the genus *Pentaneura* and one specimen of *Tendipes fulvipilus* (Rempel) were detected breeding in the flocculent organic matter of the panic grass area in September. *Culex restuans,* normally a cool weather species, was not collected after its spring appearance until the first week in September. Larvae of *C. tarsalis* were collected in the seep for the first time on September 30 in both the mud plantain (*Heteranthera*) and panic grass zones. Subsequent collections on October 5, 11, and 19 showed *C. tarsalis* present in association with *A. quadrimaculatus, A. punctipennis, C. pipiens, C. restuans, C. salinarius,* and *C. territans*. Collections on November 1 and 15 showed larvae of *C. pipiens, C. restuans, C. salinarius, C. tarsalis, C. territans,* and *A. punctipennis* still present. In the October collections, culicine species reared from the seep were represented numerically as follows: *C. pipiens* (40), *C. salinarius* (15), *C. tarsalis* (12), *C. territans* (3), and *C. restuans* (3). The collections for November 1 and 15 showed the following distribution for the culicine larvae and pupae: *C. pipiens* (63), *C. salinarius* (10), *C. restuans* (6), *C. tarsalis* (2), *C. territans* (2), and *Culiseta inornata* (1). From these field collections it appears that two broods of *C. tarsalis* were developed from the late September to mid-November portion of the 1955 growing season at Camp Tyson, Tennessee. Larvae of *C. inornata* were collected for the first time at this site on November 15, 1955. A final collection on December 9 revealed only larvae of *C. salinarius* (4) and *C. inornata* (2) beneath thin ice in a clump of *Paspalum* flooded to a depth of 4 inches.

It has been thought that *C. tarsalis* might invade small pooled areas in stream beds during seasonal drought in the fall. Since adults of this species had been collected from a barn adjacent to Jonathan Creek near Hardin, Kentucky, during the fall of 1954, dipping records were made at Jonathan Creek in 1955. While stream pools were negative, a seepage area draining through a hog lot into the creek was discovered on October 10. At this time larvae and pupae of *C. pipiens, C. restuans, An. punctipennis, An. quadrimaculatus,* and one specimen of *Ae. vexans* were present in grassy hoofprints about the seepage area. The collection (50 dips) of November 1 showed *C. tarsalis* (1) present with *C. territans* (4), *C. pipiens* (20), *C. restuans* (25), and one pupa of *C. salinarius*. Larvae of *A. punctipennis* (47) were most abundant. Small numbers of *C. inornata* (8) were recorded also. By November 15, no further breeding of either *C. tarsalis* or *C. salinarius* was detected, though the other species found on November 1 were still active. On December 9, only two larvae of *C. inornata* were present in a deep pool where the seep water entered the creek.

Isolated pools in stream beds near Camden and Hustburg, Tennessee, have also been sampled for *C. tarsalis* but with negative results.

HABITATS IN ALABAMA. The appearance of *C. tarsalis* in light trap collections at Florence, Alabama (McFarlands Bottom) during October 1953 prompted inspection of likely productive sites in the reservoir basin during 1954 and 1955. Larvae of *C. tarsalis* (34) were first found in a construction pit near the grassy margin of the reservoir on September 17, 1954, in association with *C. pipiens* (85), *C. salinarius* (2), *A. quadrimaculatus* (7), and *A. punctipennis* (10). Inspection of polluted pools in an arm of Cypress Creek adjacent to the construction pit showed only *C. pipiens, C. restuans,* and *A. punctipennis* present on October 8. A subsequent collection from these pools on November 22

showed larvae and pupae of *C. tarsalis* (6) with *C. restuans* (5), *C. pipiens* (17), *C. inornata* (2), *An. punctipennis* (2), and *Ae. vexans* (1). Inspection of the Cypress Creek arm the following week, however, showed all the associated species to be present except *C. tarsalis*.

In 1955, the polluted arm was sampled heavily during the fall, but no specimens of *C. tarsalis* appeared in the thousands of culicine larvae reared, nor were any adults found in the light trap. An extremely heavy *C. pipiens* population was present and required larviciding in the latter part of October and November. Two species of midges, *Tendipes fulvipilus* and *T. decorus* (Joh.), were also very frequent in the polluted reservoir area.

Discussion. In examining the records of captures by light trap at army installations in the Southeastern States in the early 1940's and in considering our own records, it is of interest that such wide variation occurs from year to year in the distribution pattern of *C. tarsalis*. For instance, specimens were captured at only one army installation (Camp Tyson, Tennessee) in 1942; however, adults appeared in light traps at 21 other installations in Tennessee and five other Southeastern States in 1943 but not at Camp Tyson. The collection of *C. tarsalis* in anopheline resting habitats inspected by TVA on Kentucky Reservoir in western Tennessee showed adults present in thirteen widely scattered locations in 1953, but in only one in 1954. The seasonal observations of habitats used by *C. tarsalis* at former Camp Tyson, Tennessee, during the past two seasons suggest that the degree and regularity of late summer and fall precipitation may be a strong factor in determining the extent of the annual appearance of this species at least in the Tennessee Valley watershed. Heavy rains early in September 1954 filled in the fireplug and ditch areas sufficiently to produce a heavy fall brood of *Psorophora* sp. and a subsequent series of *C. tarsalis* three and four weeks later. In 1955, however, while the same sequence was repeated at the grassy ditch, drier soil at the fireplug area after the leak was stopped in midsummer supported water for only a few days and even the *Psorophora* did not have time to emerge. Inability of fall rain to maintain sufficiently favorable breeding sites such as intermittently flooded ditches and seep areas for a month or so in the fall could therefore influence the persistence of a species generally evident only during the latter part of the growing season.

On the other hand, the condition of certain relatively permanent aquatic habitats may determine their suitability for invasion by *C. tarsalis* in the fall. Streams and ditches normally free flowing in spring and early summer frequently pool out and gradually go dry in the fall. Seasonal recession and cyclical fluctuation of Pickwick Reservoir in connection with the malaria control program of TVA reduced water elevation in the polluted arm of Cypress Creek at Florence to the bottom of the ditch by October 1954. Pools left just above the receding reservoir water did not become productive of *C. tarsalis* until late in November, though *A. punctipennis, C. restuans,* and *C. pipiens* were found as early as the first week in October and persisted through November. Larvae of *C. tarsalis* were first taken in the bottom of a sewer line construction pit near the polluted ditch on September 17 so they were available for invasion of the polluted ditch at a much earlier period than when finally found there on November 22. Because of the large number of *C. pipiens* present, it is possible that they may have been present earlier but not readily detected.

Summary. Records of light trap collections at army installations and adjacent to TVA reservoirs show that wide variations occur from year to year in the distribution pattern of *C. tarsalis*. Larvae collected from grassy seeps and intermittently flooded ditches at former Camp Tyson near Paris, Tennessee, in 1954 and 1955 substantiate previous observations east of the Mississippi River that *C. tarsalis* occurs in the fall of the year generally

from late August to late November with a peak in September. In 1955, evidence of at least two broods during this period was obtained. In the larval habitat, *C. tarsalis* was usually associated with *C. pipiens* and *A. punctipennis* though frequently with *C. restuans, C. salinarius,* and *C. territans.* In intermittently flooded ditches, millet (*Echinochloa crusgalli*), fantail (*Setaria geniculata*), and Bermuda grass (*Cynodon dactylon*) were the principal plants encountered, whereas in grassy seeps they constituted the marginal vegetation along with the emergent forms such as mud plantain (*Heteranthera reniformis*), panic grass (*Panicum dichotoiflorum*), and *Paspalum* sp.

The degree and regularity of late summer and fall precipitation sufficient to maintain temporary habitats may be an important factor in determining the extent of the annual appearance of this species. At Florence, Alabama, larvae of *C. tarsalis* invaded excavation pits in a sewer line construction area in September 1954, but were not found in nearby polluted backwater pools of a lateral drain on the Cypress Creek arm of Pickwick Reservoir until November of the same year. In general, *C. tarsalis* favored small pooled areas such as grassy ditches, seeps, hoofprints, and polluted pools rather than large bodies of fresh or polluted water of a more permanent nature. It was not found in leafy pools of rocky stream beds.

ACKNOWLEDGMENTS

The authors wish to express their sincere appreciation to Dr. G. E. Smith, Chief Biologist, Division of Health and Safety, for his direction and guidance during the course of these investigations. Dr. T. F. Hall, Staff Botanist, rendered valuable assistance with the characteristic plants of the larval habitats. Special thanks are due Mr. J. B. Moore, Division of Health and Safety, for help in connection with the field collections. Grateful acknowledgment for determination of the Tendipedidae and Heleidae (in part) is extended to Dr. Willis Wirth, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

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The "Operational and Scientific Notes" section, which follows, is a new section begun with Vol. 16, No. 1, of *Mosquito News.* It is designed to accommodate short contributions which have to do with field operations or observations on the one hand, or laboratory techniques on the other. Items in these categories can therefore be included while they are still of current interest, whereas longer items frequently have to wait for several issues when there is a backlog of longer, more formal papers.

Attention is also called to the "News and Notes" section which is compiled by Austin Morrill. Austin has made this section one of the departments to which many of our members turn first, to learn what has been going on and who has been doing what. A glance at this section in this issue will indicate what type of items we like to have for it and how they are handled. News and Notes should be addressed directly to Austin Morrill. The Operational and Scientific Notes should be addressed to the editorial office in Albany, N. Y.

OPERATIONAL AND SCIENTIFIC NOTES

An Improved Guinea Pig Restrainer. In a previous note Jones and Scheltema ('52) described and figured a small-animal restrainer designed for feeding mosquitoes in small cages. The disadvantages of this restrainer were: (1) it was not durable, being made of wood and wire, (2) it had no facilities for catching feces and urine, (3) it allowed mosquitoes to roost underneath the movable platform, and (4) it permitted nervous guinea pigs to move slightly, sometimes making it difficult for the mosquitoes to obtain full blood meals.

Several simple changes in the restrainer effectively eliminate all of these disadvantages. As shown in figure 1 the restrainer is made entirely of metal, is equipped with door guards (DG) that fit over the rack bars and sliding doors, contains fine wire screening inside the loops, has a fecal and urine tray (FU) with one end open, making washing easy, and has a handling metal tray (HT). The sliding doors are not shown.

Mosquitoes feed easily and to repletion undisturbed through the wire screening. The restrainer can be easily built by metal shops, is very durable, entirely prevents entrance of mosquitoes into the restrainer, is easily cleaned, handled, and stored.

We are much indebted to Douglas Walton and Clifton Brown for making the restrainer.—Jack Colvard Jones, U. S. Department of Health, Education, and Welfare Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Bethesda, Maryland.

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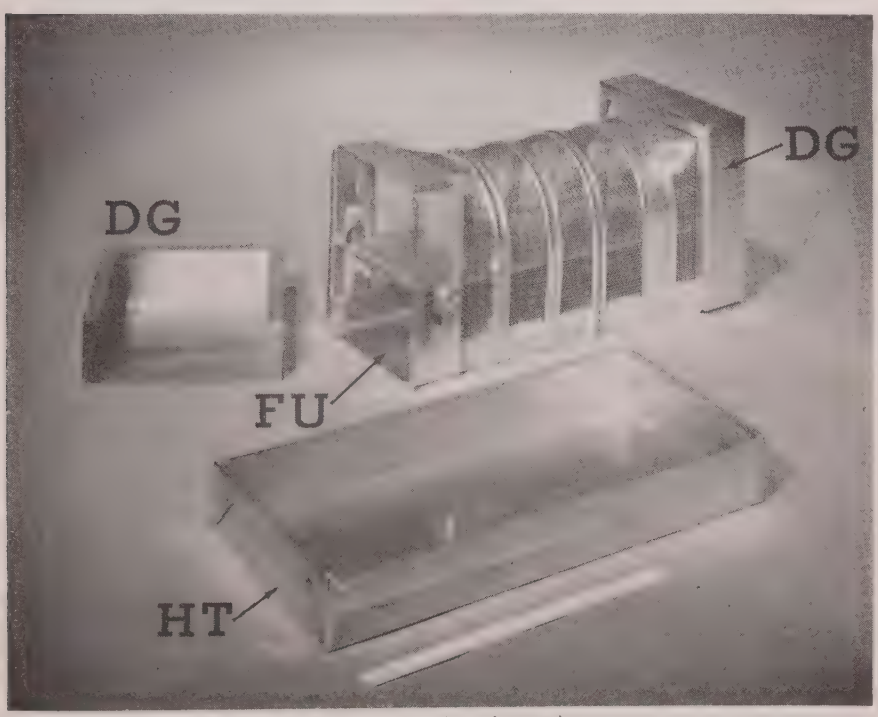

1. Disassembled guinea pig restrainer.

THE HIBERNATION OF *Uranotaenia sapphirina* (Diptera: Culicidae). The adults of *Uranotaenia sapphirina* (Osten-Sacken) have been known for a number of years to hibernate. Lawlor (1935) and Hinman (1935) have published records of overwintering females. Lawlor took a total of five females throughout the winter in a small cave near South Bethelehem, New York, while Hinman reported millions overwintering on the inside of an old fort in Louisiana. However, Pratt (1946) states that in the warmer latitudes they will breed continuously throughout the year.

In view of the scarcity of records of overwintering adults the following may be of interest: Twin Lakes, Litchfield County, Connecticut, October 23, 1954. These were taken in a small cave several hundred yards in length with many passages and chambers. The opening to the cave is partially blocked by rocks so that the actual opening is only several feet in diameter, but, inside the obstruction, the cave opens up into a chamber large enough to stand in. It was in this area, only several yards inside, that the mosquitoes were resting. Twenty females were taken in five minutes collecting with a small pocket killing bottle. When disturbed they flew readily to an adjacent rock before settling again. Also taken in company were two females of the *Aedes excrucians* group (badly worn).

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PRATT, H. D. 1946. The genus *Uranotaenia* Lynch-Arribalzaga in Puerto Rico. Ann. Ent. Soc. Amer. 39:576–584.—Oliver S. Flint, Jr., Department of Entomology and Limnology, Cornell University. Ithaca, N. Y.

SPIROCHAETAL INFECTIONS OF SALIVARY GLANDS OF MOSQUITOES. Spirochaetal infections of mosquitoes have been found and described in both larvae and adults of many species. Jaffé (1907) proposed the name *Spirochaeta culicis* for the organism he found in the intestine of culicine larvae and in the Malpighian tubes of one culicine adult (Sinton and Shute, Jour. Trop. Med. and Hyg. 42(9):125–6, 1939). Most workers have found similar spirochaetes in the organs as described by Jaffé (1907), but they have not named them. Sinton and Shute (1939) claimed to be the first reporters of such an infection in the salivary glands of a specimen of *Anopheles maculipennis* var. *atroparvus*. The organism found by Sinton and Shute (1939) was said to be morphologically indistinguishable from *Spirochaeta culicis* Jaffé, and not pathogenic to man. Masseguin *et al.* (Bull. Soc. Path. Exot. 47(2):234–6, 1954) and Masseguin and Palinacci (Bull. Soc. Path. Exot. 47(3):391–2, 1954) reported the presence of spirochaetes, morphologically similar to those of the relapsing fever group, in the salivary glands of *Anopheles funestus* and *A. gambiae,* respectively. They stated that the origin of the spirochaetes is obscure.

During the malaria survey in the mountainous area of Northern Thailand in 1954, we had encountered a female specimen of *Anopheles jeyporiensis* var. *candidiensis* in which a large number of living spirochaetes was found in its salivary glands. Unfortunately, we had no way to study further whether they were pathogenic to man or animals. The infected salivary glands were fixed and stained with the J.S.B. stain (Singh and Bhattacharji, Ind. Med. Gaz. 79:102–4, 1944) which was the only stain we had at that time.

The insect was collected from a dwelling house in the Village No. 7, Fang District, Chiengmai Province, on May 25, 1954. Malaria was hyperendemic in this area, but relapsing fever has not been recorded so far. Now malaria is being controlled by DDT residual house spraying.

The spirochaete varied from 9μ to 23μ, with the average of 14.8μ in length. About 78 percent of them varied from 11μ to 17μ. The width was about 0.3μ to 0.4μ. The undulations were 2 to 6 in number, and were about 4μ apart. The depth of curves in regular forms was about 2μ. In comparing with the spirochaete found by Sinton and Shute (1939), this organism was quite similar in both size and shape. Its origin and pathogenicity are obscure.

The writer is indebted to Mr. Sweg Prinyapol, his assistant, for giving valuable information, and for staining the specimen.—Vimol Notananda, Medical Officer, Malaria Control Unit, Chiengmai, Thailand.

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ASSOCIATION NEWS

MINUTES OF THE 12TH ANNUAL MEETING OF THE AMERICAN MOSQUITO CONTROL ASSOCIATION HELD AT BEAUMONT, TEXAS, FEBRUARY 5–8, 1956

Recorded and Reported by A. W. Lindquist and A. F. Geib

Board of Directors: The Board of Directors of the American Mosquito Control Association was convened at 2:45 p.m. February 5, at the Hotel Beaumont by President Peters.

All except four of the Board members were in attendance. Present were: F. H. Stutz, A. W. Lindquist, L. W. Smith, T. G. Raley, R. E. Dorer, D. M. Jobbins, S. V. Minnich, Charles F. Scheel, G. Edwin Washburn, C. M. Gjullin, Don M. Rees, A. W. A. Brown, and R. L. Vannote. Several committee chairmen and members of the Association were present at times during the meeting.

A motion was made by S. V. Minnich to approve the minutes as published in the June 1955 issue of *Mosquito News*. Seconded by Lester W. Smith and carried.

President Peters appointed the following to the Resolutions Committee: C. R. Twinn, D. M. Jobbins, and Lt. Commander John M. Hirst.

President Peters presented his report on important developments and progress during the year. S. V. Minnich moved and A. W. A. Brown seconded the acceptance of the report. Carried. Attachment #1.

R. E. Dorer presented and moved the adoption of the report of the Nominating Committee. Seconded by Don M. Rees. Carried. At this point A. W. A. Brown resigned as Regional Director of Canada because of being away on a foreign assignment. His term of office had one more year to run. Lester Smith moved and G. Edwin Washburn seconded acceptance of the resignation, and the appointment of B. Hocking, Assistant Professor of Entomology, University of Alberta, as Regional Director for Canada. Motion carried. Carl August Nau had previously resigned by letter to President Peters. A motion was made by D. M. Jobbins and seconded by S. V. Minnich to accept the resignation and appoint Don W. Micks, Department of Preventive Medicine and Public Health, University of Texas, as Regional Director of the Gulf Region. Carried. Attachment #2, with amendments.

Treasurer Lester W. Smith presented a report on the financial affairs of the Association. A certified public accountant had examined the records at Metuchen, New Jersey, and found them satisfactory. Mr. Smith stated that sale of Bulletin #3 had brought in sufficient funds to pay for the cost of printing. Finances of the Association were discussed by several members at this time, and there was general agreement that the fiscal affairs were in good condition. G. Edwin Washburn moved acceptance of the report and auditor's statement. Seconded by S. V. Minnich. Carried. Attachment #3.

The Committee on Finance report was presented and after discussion, acceptance was moved by Don M. Rees and seconded by R. E. Dorer. Carried. Attachment #4.

The budget for 1956 as presented by the Treasurer and Committee on Finance was studied and discussed in some detail. It was moved by R. E. Dorer and seconded by S. V. Minnich that the report be accepted with the following amendment: A total of $500, instead of $300, for travel expense if needed by the Editor of *Mosquito News,* Executive Secretary, Treasurer, or other officers to attend national

meetings and an additional $15.00 be allowed for Exchange postage. Motion carried. T. G. Raley moved the inclusion of $150 to assist program committees in early announcement of, and other matters relating to annual meetings. Seconded by A. W. A. Brown. Carried. Attachment #5.

President-Elect Stutz reported on the program developed for the Beaumont meeting. There were difficulties in arrangements and other matters, but they were all resolved satisfactorily. C. M. Gjullin moved the acceptance of the report, which was seconded by S. V. Minnich. Carried.

Report of the Public Relations Committee was presented by R. E. Dorer. Several aspects of the report were discussed and the Chairman, Ernestine B. Thurman, was commended for the careful work and thought given to more and better public relations. Acceptance of the report was moved by R. E. Dorer. Seconded by C. M. Gjullin. Carried. Attachment #6.

The report of the committee on the publication of *Mosquito News* was presented by C. R. Twinn. There was some discussion on the need for reducing tabular material of papers submitted for publication. The Editor always gets in touch with the authors on any rearrangements or reductions except on rare occasions when authors cannot be reached by mail. T. G. Raley reminded the Board that back issues of *Mosquito News* are in big demand and command a good price. Anyone wishing to donate back copies to the Association should communicate with Walter D. Henderson. Acceptance of report was moved by T. G. Raley and seconded by F. H. Stutz. Carried. Attachment #7.

The report of the Standing Committee on Sales of Advertising Space was presented by Francis P. Creadon, Chairman of the Committee who took over from W. E. Bickley, who could not continue as Chairman for all of 1955. The Board listened with interest to Mr. Creadon's plans to expand advertising in *Mosquito News* and other publications. It was moved by D. M. Jobbins and seconded by A. W. A. Brown that the report be accepted. Carried. Attachment #8.

The report of the Editor of *Mosquito News,* Donald L. Collins, was presented by Fred H. Stutz. This excellent summary of accomplishments was commented upon favorably by several Board members. T. G. Raley moved acceptance of the report which was seconded by D. M. Jobbins. Carried. Attachment #9. The Editor recommended in his report inclusion of a new section or department in *Mosquito News* dealing with notes of a scientific nature on research and field observations. Motion approving the new section was made by F. H. Stutz and seconded by G. Edwin Washburn. Carried.

A report of the Good Neighbor Club was read by Archie Hess, the Chairman of the Committee. The Board expressed approval of the good progress made by Dr. Hess in furthering the efforts of the Good Neighbor Club. Motion of acceptance of the report was made by S. V. Minnich and seconded by Lester Smith. Carried. Attachment #10.

A report of sales of miscellaneous publications by Chris Williamson was given by Lester Smith. Don Rees moved acceptance of report. Seconded by A. W. A. Brown. Attachment #11.

Lt. Commander Hirst presented a verbal report for the Miscellaneous Publications Committee. Good progress has been made in assembling material for Bulletin #4, "Organization for Mosquito Control." Fourteen chapters are included, and the present problem is the editing and coordinating the Bulletin so as to present a good story for those seeking information on how to effectively organize for control of mosquitoes. The question was raised if the Board wants to proceed with Bulletin #4. G. Edwin Washburn moved that the authority be given to the Committee to prepare the Bulletin. Seconded by Don M. Rees. Carried. The question of carrying advertising in Bulletin #4 was discussed. Motion that the Bulletin carry advertising was made by S. V. Minnich

and seconded by A. W. A. Brown. Carried. General discussion suggested the Committees on Advertising and Miscellaneous Publications work out methods of handling advertising in Bulletin #4.

The Membership Committee report was presented by Thomas D. Mulhern. He reviewed efforts to obtain new members by encouraging the regional directors to work on new memberships in their respective areas. He had suggested approaches by personal contact and letters. The number of members had held its own during 1955. A good deal of discussion ensued on how to interest new members in the Association without resorting to pressure techniques. A motion was made by R. E. Dorer to legally vote in the 107 new applicants plus those obtained by the Good Neighbor Club. Seconded by A. W. A. Brown. Carried.

(No written report received.)

The report of the Historical Committee, of which Harold F. Gray is Chairman, was read by President Peters. Acceptance was moved by C. M. Gjullin and seconded by T. G. Raley. Carried. Attachment #12.

Dr. Bailey Pepper, Chairman of the Committee on Bylaws, presented a revision of the American Mosquito Control Association bylaws. This Committee has worked diligently on streamlining and eliminating excess verbiage of the present bylaws. The Committee recommended that the Board and membership study carefully the revision so action could be taken on adoption at the next annual meeting. Lester Smith moved to accept the revision for study and the proposal for action by the membership at the next annual meeting. Seconded by C. M. Gjullin. Carried.

John A. Mulrennan gave a verbal report of the Committee on Legislation. The most important event was the proposed Federal legislation providing for research and demonstration of mosquito control. Following resolutions by the American Public Health Association, the Association of State and Territorial Health Officers, the Florida Anti-Mosquito Association, and the Oregon Vector Control Association, a bill, S-2870, was introduced into the Senate on January 9, 1956, by Senator Spessard Lindsey Holland of Florida. There followed a lengthy discussion on the legislation. The view was expressed by several members that the bill did not provide for a comprehensive and broad approach to mosquitoes in relation to agriculture. There was unanimity on the need for expanding research on all aspects of mosquitoes and their control and that the American Mosquito Control Association had a vital interest in mosquito research and demonstration. Don M. Rees moved to accept the report and study the bill. Seconded by T. G. Raley. Carried. President Peters instructed the Legislation Committee to work up appropriate statements in the form of resolutions to be presented at the general business meeting.

The National Adviser, Robert Vannote, reviewed briefly his activities during the year. He had assisted several officers and committees with advice on procedures and actions necessary for the welfare and progress of the Association. G. Edwin Washburn moved acceptance of the report. Seconded by S. V. Minnich. Carried.

The President-Elect in behalf of the Florida Anti-Mosquito Association invited the Association to meet with them in Miami Beach in early April, 1957. T. G. Raley moved acceptance. Seconded by C. M. Gjullin. Carried.

Board meeting adjourned 12:30 a.m.

During the meetings Monday, February 6th, the Nominating Committee Report was presented by Chairman Dorer.

General Business Session, February 7, 9:00 P.M.

President Peters opened the general business meeting by having a report of the Treasurer. Acceptance moved by D. M. Jobbins and seconded by Harry Pratt. Carried. Attachment #3.

F. H. Stutz reported on efforts of the Program Committee for the 1956 annual meeting. Acceptance of report was moved

by S. V. Minnich and seconded by R. E. Dorer. Carried.

R. E. Dorer reviewed the report of the Public Relations Committee. Acceptance was moved by William J. Buchanan and seconded by Archie Hess. Carried. Attachment #6.

A report of the Committee on Publication of *Mosquito News* was presented by C. R. Twinn. George Thompson moved acceptance. Seconded by G. Edwin Washburn. Carried. Attachment #7.

Archie Hess reported on the Good Neighbor Club. R. E. Dorer moved acceptance of report. Seconded by Don Johnson. Carried. Attachment #10.

A report of the Committee on Miscellaneous Publications was given by Commander Hirst. Acceptance moved by Bruce Brockway. Seconded by Franklin Wray. Carried.

Dr. Bailey Pepper reported on the Bylaws Committee. Acceptance moved by G. Edwin Washburn and seconded by Don Rees. Carried.

T. G. Raley reported on minutes of 1955 published in the 23rd Proceedings and Papers of the California Mosquito Control Association. Acceptance moved by John Mulrennan. Seconded by Robert Vannote. Carried.

The budget was reviewed briefly by Lester Smith. Acceptance moved by Franklin Wray. Seconded by R. E. Dorer. Carried. Attachment #5.

The Executive Secretary asked the membership to approve the expenditure of $200 for travel of the Secretary and Treasurer to the 1956 annual meeting. (The 1955 budget carried $300 for travel purposes.) Acceptance moved by George Thompson and seconded by Bruce Brockway. Carried.

Committee on Research and Development reported through Chairman Maurice W. Provost. Acceptance moved by Lt. Commander Hirst. Seconded by Lester Smith. Carried.

The Chairman of the Committee on Finance reported on the past year's activities. Acceptance moved by G. Edwin Washburn. Seconded by C. M. Gjullin. Carried. Attachment #4.

President Peters called for the Resolutions Committee report. Chairman C. R. Twinn presented the following:

—1—

RESOLUTIONS OF THANKS

1. To the Jefferson County Mosquito Control Association and members of the local committees for the excellent arrangements, both business and entertainment, that contributed so largely to the success of the 12th annual conference of the American Mosquito Control Association at Beaumont, Texas.

2. To the Galveston County Mosquito Control District officers for organizing the field trip through the coastal marsh country to Galveston.

3. To all those who presented papers or in other ways contributed to the success of the meetings.

4. To the management and staff of the Hotel Beaumont for the fine facilities and service provided during the conference.

5. To the local press for the generous publicity given to the conference program and proceedings.

6. To the Beaumont Chamber of Commerce for their valuable assistance to the local committees and to the members.

C. R. Twinn moved acceptance. Seconded by S. V. Minnich. Carried.

—2—

RESOLUTION ON WORLD HEALTH ORGANIZATION THEME

WHEREAS The World Health Organization has chosen for the theme of World Health Day, April 7, 1956, the slogan, "Destroy Disease-Carrying Insects," and

WHEREAS The American Mosquito Control Association is vitally interested in promoting the control of mosquitoes and other disease-bearing arthropods in the United States and throughout the world, therefore,

BE IT RESOLVED: That this Association endorses and heartily concurs with this theme and recommends that all individuals concerned with mosquito control publicize and promote this slogan of World Health Day.

A copy of this resolution to be sent to Dr. M. G. Candau, Director-General, World Health Organization, Geneva, Switzerland.

F. H. Stutz moved acceptance. Seconded by Lt. Commander Hirst. Carried.

—3—

RESOLUTIONS FOR CONGRESSIONAL ACTION

The following two resolutions were read by C. R. Twinn.

1. WHEREAS The American Mosquito Control Association, Inc., within the stated objectives of its bylaws is dedicated to the furtherance of research on mosquitoes and their control,

BE IT RESOLVED: That the Congress of the

United States provide necessary funds to the U. S. Department of Health, Education and Welfare and the U. S. Department of Agriculture to undertake a comprehensive program of research, demonstration, and consultation on pest and other mosquitoes, to develop ways and means of alleviating the serious mosquito problems in relation to public health and agriculture.

Be It Further Resolved: That a copy of this resolution be transmitted to the Secretaries of Health, Education, Welfare and Agriculture and to all members of the United States Senate and House of Representatives.

2. Whereas: The American Mosquito Control Association, Inc., within the stated objectives of its bylaws is dedicated to the furtherance of research on mosquitoes and their control, and whereas Senate Bill 2870 and corresponding House of Representatives Bills propose to make possible the conduct of greatly needed research, technical development, and control demonstrations on pest mosquitoes throughout the United States:

Now Therefore Be It Resolved: That this Association does herewith and hereby endorse and urgently urge passage of this significant legislation by the Congress of the United States, *providing that this Bill and the operational plan* pertaining to it contain or incorporate the following:

1. The U. S. Department of Agriculture engage in all aspects of research pertaining to mosquitoes in relation to agriculture.

2. The amount of funds allocated the U. S. Department of Agriculture be substantially increased to permit investigations on mosquitoes in relation to agriculture.

3. At least one-half (50 percent) of the funds derived be applied to research on mosquitoes to develop methods for control.

4. Where practical and desirable, existing research organizations and facilities be utilized to the maximum in effecting the operational plan.

Be It Further Resolved: That copies of this resolution be transmitted to the United States House of Representatives; the United States Senate; the United States Department of Health, Education, and Welfare, and the United States Department of Agriculture.

A motion was made by John Mulrennan to table the first resolution. Seconded by Lester Smith. Motion carried. The second resolution was discussed by some of the members and John Stivers moved its adoption. Seconded by John M. Hirst. Voting was by show of hands, 43 "yes" and 13 "no." Motion carried by necessary three-fourths vote.

Under New Business, it was moved by T. G. Raley that $66 collected by a free-will offering be deposited with the Treasurer and that $40 be added from Association funds for a total of $100 to be presented to the Melody Maids for use in travel. Seconded by C. M. Gjullin. Carried.

The report of the Nominating Committee was read, and the President called for nominations from the floor. There being none, H. D. Peters moved that nominations be closed and that the Secretary be instructed to cast a unanimous ballot for those nominated. Seconded by Robert Vannote. Carried. Attachment #2.

F. H. Stutz on behalf of the Florida Anti-Mosquito Association invited the American Mosquito Control Association to meet with them in early April 1957 at Miami Beach, Florida. Invitation accepted.

Business meeting adjourned 9:55 p.m.

Minutes of the Meeting of the Board of Directors American Mosquito Control Assn.

10 p.m., February 7, 1956—Beaumont, Texas

Present: Fred Stutz, Richard Peters, Arthur Lindquist, Ted Raley, John Hirst, Rowland Dorer, Robert L. Vannote, Charles F. Scheel, Lester Smith, Samuel V. Minnich, C. M. Gjullin, D. Manley Jobbins and A. F. Geib.

The meeting was called to order by President Fred Stutz. The first matter discussed was the publication of the papers of the Annual Meeting. It was agreed that President Elect, Arthur Lindquist, would handle this business and see that the papers would be published in regular issues of *Mosquito News* in the customary manner.

Lester Smith moved that all business transacted and the minutes of the Annual Meeting of the American Mosquito Control Association be published in the June issue of *Mosquito News*. Mr. Minnich seconded, and the motion carried.

Mr. Raley moved that Arthur Lindquist be made Chairman of the Program Committee for 1956–57 and he be allowed to appoint the other members to this com-

mittee. Mr. Minnich seconded. Motion carried.

Mr. Minnich moved that the 1957 Annual Meeting of the American Mosquito Control Association be held at Miami Beach, Florida, April 14, 15, 16, and 17, 1957. Mr. Raley seconded. Motion carried.

John Hirst moved that, based on precedent, the composition of the nominating committee provide regional representation through the following individuals: Richard F. Peters, Chairman, Pacific Southwest Region; Milton H. Buehler, Pacific Northwest Region; J. Melton Williams, Southeast Region; Richard B. Eads, Gulf Region; William J. Buchanan, North Central Region; Don M. Rees, Rocky Mountain Region; Robert L. Vannote, Northeast Region; Rowland E. Dorer, Central East Region; C. R. Twinn, Canada; Eulogio Bordas, Mexico, Central and South America. Mr. Lester Smith seconded. Motion carried.

Mr. Raley moved that a letter of commendation be sent by President Fred Stutz to Don Collins' superior as an expression of acknowledgement and appreciation for the exceptional services rendered the American Mosquito Control Association by Dr. Collins and his secretary, Mrs. Slater. Mr. Lester Smith seconded. Motion carried.

Mr. Rowland Dorer moved that the existing Legislative Committee be retained. Mr. Samuel Minnich seconded. Motion carried.

Mr. John Hirst moved that the Research and Development Committee be retained. Mr. Samuel Minnich seconded. Motion carried.

Mr. Jobbins moved that the Committee on Finance be continued as is. Mr. Sam Minnich seconded. Motion approved.

Mr. Peters moved that, on the Advertising Committee, Mr. Francis Creadon be made Chairman, and the other members remain the same. Mr. Minnich seconded and the motion carried.

Mr. Lester Smith moved that the present Committee on Bylaws be retained, and that the Board of Directors of the Association review and comment on the proposed changes submitted by this Committee at these meetings; the Committee will reedit and return to the Board for review and approval for ultimate disbursing to the Membership through the Office of the President. Mr. Minnich seconded. Motion carried.

Mr. Raley moved that the present Public Relations Committee be retained, and that R. L. Vannote work with the Committee Chairman to outline the duties of the Committee. Mr. Smith seconded and the motion carried.

Discussion was held concerning the liaison between the Program Committee (Lindquist) and the Committee for Local Arrangements (Stutz for the next Annual Meeting). It was agreed that matters in this category could best be handled directly between Fred Stutz and Arthur Lindquist.

Mr. Peters moved that the Good Neighbor Committee be retained. Mr. Smith seconded, and the motion carried.

Mr. Peters moved that the Historical Committee be retained the same for another year. Mr. Minnich seconded, and the motion carried.

Mr. Hirst moved that Mr. Don R. Johnson be made Chairman of the Membership Committee, with the Committee membership to consist of the Regional Directors of the Association. Mr. Lindquist seconded, and the motion was approved.

Mr. Raley moved that the Committee on Miscellaneous Publications be retained the same for another year, and that Mr. Hirst be instructed to attempt to get the Surgeon General to write the preamble for Bulletin #4. Mr. Lindquist seconded and the motion carried.

President Fred Stutz reappointed R. L. Vannote as National Advisor to the American Mosquito Control Association.

There being no further business, Mr. Minnich moved that the meeting be adjourned. Mr. Raley seconded, and the motion carried at 1 a.m.

ATTACHMENT #1

President's Report
to the
Board of Directors
American Mosquito Control
Association, Inc.
February 5, 1956

Accomplishments of the year 1955 in the furtherance of our Association's objectives will not stand out distinctively by themselves. Rather, I would say the year 1955 was largely devoted to supporting and strengthening trends already in progress. Your President can only point to a modest four inches of correspondence conducted in behalf of the Association during the year.

In reviewing the calendar, the following features and developments seem worthy of mention:

1. Following upon the 11th Annual Meeting of the Association at Los Angeles, word was received that the Northeastern Mosquito Control Association, comprising the New England States, New York and Pennsylvania was organized February 2, 1955.

2. Shortly thereafter, a meeting of mosquito control workers in Illinois resulted in a reconstitution and rededication of the Illinois Mosquito Control Association.

3. In co-authorship with Ted G. Raley, Executive Secretary, a paper was prepared, "A Report of Activities of the A.M.C.A. for 1954," which was read at the March meeting of the New Jersey Mosquito Extermination Association at Atlantic City.

4. Commander John M. Hirst began active work in his capacity as Chairman, Miscellaneous Publications Committee, by outlining and parceling out assignments for prospective A.M.C.A. Bulletin No. 4, "Organization for Mosquito Control." A first draft of this proposed Bulletin was liberally distributed to active Association members during December.

5. The March 18, 19, 1955, meeting of the Utah Mosquito Abatement Association was attended and a review of highlights of the A.M.C.A.-C.M.C.A. joint meeting at Los Angeles was presented.

6. An effort was undertaken toward the close of March to stimulate the Regional Directors to perform actively the following functions:

a. Initiate advisory and consultative contacts to localities within their individual regions (representing the Association) where mosquito problems exist and where their technical and administrative knowledge would be helpful.
b. Serve as direct agents in securing new Association members who could and should be a part of our Association.
c. Serve as agents of the Miscellaneous Publications activities to assist in securing sales of our Bulletins 2 and 3 which remain in supply.
d. Help the Advertising Manager obtain additional advertisements for "Mosquito News," such advertisements to be sought from firms located in each region.
e. Encourage and transmit articles to "Mosquito News" which represent the advances being made on the mosquito control front in each region.

Regrettably, it is only possible to report that much remains to be accomplished generally in attaining these goals. There are significant exceptions.

7. Dr. Archie D. Hess really dug into and rejuvenated the Good Neighbor Club program in his capacity as Chairman, doing himself, his Committee and the Association proud by his accomplishments.

8. Things began to happen down Texas way with Brazoria County, Galveston County, and two other counties developing budding mosquito control programs, which, combining with pioneer Jefferson County, gave rise in May to the South Texas Mosquito Control Association. I was unable to refrain from kidding George Thompson by venturing that their slogan undoubtedly reads: "The Biggest Little Association in the Americas!"

9. Dr. Bailey B. Pepper, Chairman, Committee on Bylaws, got off to a strong start on revision of the Association Bylaws,

was interrupted by obstreperous New Jersey mosquitoes, and closed with a driving finish to complete his Committee's proposed changes a couple of weeks ago.

10. After months of negotiation and letter writing, Francis P. Creadon accepted the post of Advertising Manager, relieving Dr. Wm. E. Bickley who had so faithfully fulfilled this function for the Association for the past couple of years.

11. In the autumn, John A. Mulrennan, Chairman of the Legislative Committee, volunteered a comprehensive statement of the mosquito control research and developmental needs of America. This statement was in support of a proposed Congressional Act (S.B. 2870 and H.R. 8400) proposed to be sponsored by the American Public Health Association, State and Territorial Health Officers Association, Regional Mosquito Control Associations, and the American Mosquito Control Association.

12. The organizational meeting of the Oregon Mosquito and Vector Control Association was attended November 17, 18, in company with Ted G. Raley, at Eugene, Oregon.

13. Lester W. Smith, our treasured Treasurer, has accomplished his vital responsibilities with characteristic efficiency; a certified audit of the Treasurer's account has been received which reveals that the fiscal affairs of the Association are in sound order. He has prepared and distributed a budget estimate for 1956 for review by the Board.

14. Ernestine B. Thurman, as Chairman of the Committee on Public Relations and Education, worked effectively with her Committee in publicizing this Conference, and in getting interest started in an Association seal and/or insignia.

15. Dr. Maurice W. Provost, Chairman of the Research and Developments Committee, came through toward the end of the year with a well conceived research plan in outline form.

16. Our President-Elect, Fred H. Stutz, has proceeded methodically and successfully to organize the splendid program which is in store for us at this meeting. Dr. Paul Meyer and George A. Thompson have effectively handled the local arrangements for the Beaumont portion of the meeting, and Dr. Don W. Micks has already demonstrated through his circular letter to the membership the degree of organization which he has developed for the Galveston portion of the meeting. The Texas State Health Department staff has also contributed significantly to the general arrangements.

17. Our Editor of "Mosquito News," Dr. Donald L. Collins, and his fine staff have continued the high standard of content in "Mosquito News" throughout 1955. A couple of issues seemed abnormally slow in coming to hand, but undoubtedly a sound reason exists to explain this.

18. Our Vice President, Dr. A. W. Lindquist, deserves favorable mention for the variety of expression and activities which he has participated in on behalf of the Association during the year.

19. Thomas D. Mulhern, Chairman of the Membership Committee, effectively coordinated this activity, working in conjunction with our Executive Secretary.

20. Robert L. Vannote, our National Advisor, lent support and encouragement when such was indicated.

21. Last, but foremost in deserving and herewith receiving praise for his service to the Association during 1955, is our Executive Secretary, Ted G. Raley. Without question, Ted Raley has demonstrated clearly to me throughout the year that his role in the Association is that of its "backbone." In fact, without the helpful assistance rendered by Ted Raley throughout the year, your President would have achieved considerably less than the record shows. As Lester has previously been referred to as a "treasure," likewise should our Executive Secretary be regarded by the Association as Ted G. (for "Gem") Raley!

In conclusion, I wish to thank the Officers and Board, the Committees, the Editorial Staff, and the general membership for having had this privilege of serving

and representing our Association in this significant capacity during 1955.

Respectfully submitted,
Richard F. Peters
President

ATTACHMENT #2

Report of the Nominating Committee

The Nominating Committee was appointed by the President and Board of Governors on January 27, 1955 at Los Angeles. Due to the untimely death of E. N. Becton, it was necessary for the Board to appoint another member from the Southeast Region. Mr. H. D. Peters was selected.

Following democratic procedure the Committee was canvassed by mail. Four ballots were necessary in order to obtain a majority vote for all of the offices to be filled. All of the nominees agreed to serve, and were elected. Their names appear on the back cover of *Mosquito News*.

Respectfully submitted,
Dr. F. C. Bishopp (Gulf)
Mr. Otto McFeely (N.C.)
Dr. H. P. S. Gillette (Mexico, Central and South America)
Mr. R. L. Vannote (N.E.)
Dr. A. D. Hess (Rocky Mountain)
Mr. H. D. Peters (S.E.)
Mr. Edgar A. Smith (P.S.W.)
Dr. C. R. Twinn (Canada)
Dr. Wm. C. Frohne (P.N.W.)
Mr. R. E. Dorer, Chairman (Central East)

ATTACHMENT #4

Report of the Committee on Finance

The committee has given serious study to several aspects of the financial status of the American Mosquito Control Association. Three of the members met in Washington, August 27, to review the duties of the committee and study plans of action. Ideas have been exchanged by telephone, letter, and personal contact. The Chairman spent several hours with the Treasurer, Lester Smith, in October. The books and fiscal records of the AMCA maintained by Mr. Smith are in excellent shape. Special accounts are coordinated in Mr. Smith's office in a very creditable manner, and no improvements or changes are suggested.

The committee discussed the purposes and needs for extra funds for the Association. As far as can be determined, the only urgent need is for more support of *Mosquito News* to take care of rising publication costs and for support of bulletins and other published material. The increase in membership and advertising is recommended as a sound means of providing extra funds. The practicability of obtaining financial support from industry, foundations, and other sources was studied.

It is recommended that efforts continue to obtain support from foundations for certain activities of the Association. Some leads now show promise of support for the bibliography section in *Mosquito News*.

The committee does not recommend any change in handling special account funds, i.e., bulletins, Good Neighbor, and advertising at this time. The work of Lester Smith is highly commended, and the Association is indeed fortunate in having such a capable and willing officer.

The annual budget has been reviewed with Lester Smith, and the committee recommends its adoption.

Respectfully submitted,
P. Bruce Brockway, Jr.
Austin W. Morrill, Jr.
Kenneth L. Knight
George E. Powers
William E. Bickley
Lester W. Smith
A. W. Lindquist, *Chairman*

Since Attachments #3 and #5 are in tabular form, it was necessary to place them out of order to permit their complete presentation on separate pages. These Attachments follow.

ATTACHMENT #3

REPORT OF THE TREASURER

REGULAR ACCOUNT

RECEIPTS AND DEPOSITS:		
Bank Balance, January 1, 1955		$4,245.41
Dues and subscriptions	$4,987.00	
Advertising	2,568.77	
Reprints	713.51	
Other sources	290.12	
Total receipts		8,559.40
		$12,804.81
DISBURSEMENTS:		
Printing and mailing of *Mosquito News*	$6,979.61	
Office supplies, postage, bank charges	489.38	
Audit of books, N. Lippman; premium on bond	55.00	
Travel expenses of officers	166.00	
Transferred to Special Publications Acct.	527.62	
1000 copies, Proceedings, N.J.M.E.A.	850.00	
Refunds to subscribers	94.50	
Total disbursements		9,162.11
Bank Balance, December 15, 1955		$ 3,642.70

SPECIAL PUBLICATIONS ACCOUNT

RECEIPTS:		
Bank balance, January 1, 1955		$ 0.00
Transfer of funds; R. Dorer	$ 32.75	
" " " Regular Account	527.62	
" " " C. T. Williamson	1,483.23	
From sale of Bulletins, etc.	226.75	
Total receipts and deposits		$ 2,270.35
DISBURSEMENTS:		
Printing	$1,179.35	
Copper plates	156.49	
Postage, telephone, etc.	15.21	
Bank charge	2.00	
Total disbursements		1,353.05
Bank balance, December 15, Special Account		$ 917.30
" " " " Regular "		3,642.70
Total funds on deposit, December 15, 1955		$ 4,560.00

Respectfully submitted,
LESTER W. SMITH, *Treasurer*

ATTACHMENT #5

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

Office of the Treasurer

BUDGET ESTIMATE 1956

PRESIDENT:		
Postage and Stationery	$ 50.00	$ 50.00
SECRETARY:		
Postage	$ 100.00	
Printing, Stationery, Forms	100.00	
Telephone, Telegrams	10.00	
Other Expense	10.00	
Bonds—Ins.:	5.00	$ 225.00
TREASURER:		
Postage	$ 76.00	
Printing, Stationery, Forms	75.00	
Telephone, Telegrams	10.00	
Audit of Books	75.00	$ 236.00
EDITOR:		
Postage	25.00	
Printing	25.00	
Printing, Stationery, Forms	25.00	
Telephone, Telegrams	25.00	
Mosquito News and Reprints, Four Issues (includes mailing)	7,000.00	$7,100.00
ADVERTISING MANAGER:		
Postage	$ 50.00	
Printing, Stationery, Forms	35.00	
Telephone, Telegrams	25.00	
Other Expense	10.00	$ 120.00
LIBRARIAN:		
Postage	$ 50.00	
Stationery	10.00	$ 60.00
BUSINESS MANAGER:		
Postage	$ 50.00	
Stationery	10.00	$ 60.00
OTHER EXPENSE:		
Travel Expense, Annual Meetings	$ 500.00	
Meeting Expense	150.00	
Postage, Exchange Accounts	15.00	
Contingencies	100.00	$ 765.00
TOTAL ESTIMATED BUDGET:		$8,616.00

ESTIMATED REVENUE 1956

	Actual 1955	Estimated 1956
Dues & Subscriptions	$5,107.00	$5,500.00
Advertising	2,568.77	2,800.00
Reprints	736.46	800.00
Sale of Bulletins & Back Issues	290.12	500.00
	$8,702.35	$9,600.00

Respectfully submitted,
LESTER W. SMITH, *Treasurer*

ATTACHMENT #6

Report of the Standing Committee on Public Relations, AMCA.

During 1955 our objectives were of two general catagories: Publicizing the 1956 annual meeting and publicizing mosquito control. Mr. George Powers, Dr. John Porter, and Dr. Richard Eads handled the publicity of the meeting while Mr. Rowland Dorer, Mr. Robert Peters, Mr. Donald Johnson, and Mr. Francis Creadon participated in publicizing mosquito control. Many projects were suggested; a great deal of correspondence was exchanged; some projects were completed; and others were studied and are pending. The wholehearted participation of the members of this committee, individually and collectively, is hereby gratefully acknowledged.

I take pleasure in presenting the following recapitulation of activities:

I. Publicizing the 1956 annual meeting:
   1. In *Mosquito News*—June, September, and December issues.
      (a) Announcement on front cover.
      (b) A centerpage spread with cuts.
      (c) Two half-page cuts.
      (d) Three-page program.
      (e) Eight page-fillers.
      Publication was sponsored by AMCA; cuts were obtained by Dr. Eads.
   2. Announcements were submitted to editors of journals:
      (a) Entomological Society of America.
      (b) Entomological Society of Washington.
      (c) American Public Health Association.
      (d) American Society of Tropical Medicine & Hygiene.
      Publication was sponsored by the society involved.
   3. "Fliers"—2000 copies distributed among district association membership. Publication was sponsored by Dade Co. Anti-Mosquito District; distribution by agencies with whom members of this committee are associated.

II. Publicizing mosquito control:
   1. AMCA membership pin. (pending)
      (a) "Parva Culex" pin designed by Mrs. Chenoweth in 1930 was considered. The original die is reported to be available at Balfour Co., Attleboro, Mass.
      (b) Design of pin by Dorer was circulated among committee members.
      (c) Committee voted to continue the project; accept the Dorer design; and to present an outline of the project to the Board of Directors when plans are finalized.
      (d) Price quotations were obtained from L. G. Balfour Co., Attleboro, Mass. (design with screw post or safety catch attachment) Sterling silver—60¢ each; 1/10—10K gold plate—$1.00 each; 10K solid gold—$3.15 each; die and tool charges—$65.00.
      (e) For consideration: Expansion of this project to meet the need for selecting a seal or insigna for AMCA as suggested by Mr. R. F. Peters, President.
   2. Posters and other eye-catching publications. (Pending)
      (a) Posters which mosquito control organizations might purchase and display.
      (b) A "Funnybook" type of publication depicting how a community might organize a mosquito control agency which interested groups might purchase.
      (c) Cards printed by an insecticide agency, advertising its products, as well as announcing the 1957 annual meeting and listing factual notes on mosquito abundance, mortality rates for mosquito-borne diseases in the world, the number of control agencies in operation, the amounts of insecticides being used annually, and the number of persons being protected.

This plan was submitted to the Agri. Chem. Div. of Shell Chemical Co. (Dr. Mortimer D. Leonard) for consideration. Plans were not finalized.

Recommendations for 1956

1. Continue the pending projects.
2. Begin early to:
   (a) Publicize the 1957 meeting in the *Mosquito News* and other journals.
   (b) Contact Chambers of Commerce in the host-area for financial support of publicity.
   (c) Contact transportation companies for advertising.
   (d) Prepare "fliers" for local district members prior to the beginning of the fiscal year, at least in time for budget planning.
3. Consider the selection of committee members, in so far as is practical, from members residing near the host-area. This will facilitate more rapid execution of plans and will offer the possibility of a committee meeting.

Acknowledgements

We should like to express our appreciation to Dr. Donald L. Collins, Editor, for the publicity in the *Mosquito News* and for his suggestions and assistance in this matter; to Mr. Fred Stutz and the Dade Co. Anti-Mosquito District for sponsoring the "Fliers"; to the various local organizations who assisted in distributing the "Fliers"; to Mr. Fred A. Reiley, Atlantic Co. Mosquito Extermination Commission for lending his "Parva Culex" pin for our consideration; and to all who have offered encouragement, suggestions, and assistance in our endeavors.

I have asked Mr. Rowland Dorer to act as Chairman of this committee and to assume all responsibilities pertaining to the chairmanship in my absence during the 1956 annual meeting in Beaumont, Texas. I regret that I am unable to attend the meeting. My best wishes and personal regards are with you during this meeting which should be one of the most interesting, profitable, and pleasant ever held by the American Mosquito Control Association.

Respectfully submitted,
Geo. E. Powers
John E. Porter
R. E. Dorer
R. B. Eads
Donald R. Johnson
R. H. Peters
F. P. Creadon
Ernestine B. Thurman
Chairman

ATTACHMENT #7

Report of the Standing Committee on Publication of *Mosquito News*. 1955.

The duties of this committee apparently have not been precisely defined. In the absence of definite instructions, the chairman has assumed that they are to advise and assist the editor of *Mosquito News* in matters of policy and procedure, and to make constructive suggestions and recommendations concerning the journal to the Board of Directors. During the past year, the editor, Dr. Donald L. Collins, has kept the committee informed, through the chairman, of matters relating to *Mosquito News,* such as suggestions to authors and action taken to reduce the cost of publication.

Since an editor is in large measure responsible for the standing and reputation attained by his journal, his job is no sinecure. The editor of *Mosquito News* is not only editor, in the ordinary sense, but also managing editor and to some extent business manager. In his own words, he has to "iron out misunderstandings with authors of papers, and to act as middleman between authors, associate editors, contributors, printers, engravers, and others." His only compensation for all this is the appreciation of his fellows and the satisfac-

tion of a difficult job well done. His work would be made easier if authors would observe carefully the requirements of the journal and follow the excellent advice and suggestions contained in his editorial in the June 1955 issue entitled: "quality, brevity, and economy." Members and other contributors should read and re-read this presentation before submitting manuscripts.

Dr. Collins has to maintain very close watch to keep costs at a minimum. Towards this end he spends considerable time and effort in persuading authors to eliminate unnecessary verbiage and to exclude non-essential tabular material and illustrations.

At present, authors or their organizations are usually required to pay for pages of manuscript in excess of six. Perhaps they should also be required to pay for costs above the normal for the printed page, such as are incurred by setting up tabular material and making cuts for illustrations.

Another method of reducing costs and, incidentally, the work of the editor would be to discontinue publishing complete reports of the business proceedings of annual meetings, which is a recent innovation. The published reports could be confined to essential matter of general interest to the membership, presented as concisely as possible. The detailed minutes could be mimeographed for distribution to members of the Board of Directors, committees, and others specially interested in the management of the Association.

Revenue from advertisers helps to cover the cost of printing *Mosquito News*. Consequently the work of the advertising manager is very important to the Association. Dr. W. E. Bickley, who did an excellent job in this capacity, resigned from the post in September, because of increased professional responsibilities and work, and the Board of Directors appointed in his place Mr. Francis P. Creadon, of the Desplaines Valley Mosquito Abatement District. The Association is very fortunate in having public spirited members like Dr. Collins, Dr. Bickley, and Mr. Creadon, who give so unselfishly of their time and talents. This remark also applies to the Associate Editors of *Mosquito News*.

DON M. REES
S. V. MINNICH
JOHN M. HIRST
W. E. BICKLEY
C. R. TWINN, *Chairman*

Jan. 31, 1956

ATTACHMENT #8

REPORT ON ADVERTISING IN *Mosquito News*

January 1, 1955 to December 31, 1955

The figures below represent transactions during the calendar year 1955 for advertising in four numbers, Volume 14, Number 4 and Volume 15, Numbers 1, 2 and 3. (December 1954 and March, June and September 1955).

Number of Active Accounts	24
Number of pages of advertising (exclusive of A.M.C.A. business)	66½
Receipts	$2,442.97
Expenses:	
Postage, telephone, telegrams	55.11
Printing, Rate Sheets, Envelopes	35.82
Honorarium for stenographer	5.00
Total expenses	$95.93

Respectfully submitted,
FRANCIS P. CREADON
Advertising Manager

Members of Standing Committee on Sales of Advertising Space: FRANKLIN C. WRAY, SAMUEL V. MINNICH, P. BRUCE BROCKWAY, JR., LT. CDR. KENNETH L. KNIGHT, GEORGE E. POWERS, ARTHUR F. GEIB, WILLIAM C. MCDUFFIE, WILLIAM S. MURRY.

ATTACHMENT #9

EDITOR'S REPORT FOR 1955

Mosquito News: FACTS AND FIGURES— VOLUME 15

Issue	No. copies printed	No. pages	Cost
March	1250	84 and Index	$1,900.86
June	1250	88	1,650.79
September	1300	72	1,465.61
December	1300	80	1,709.27
Total	5100	324	$6,726.53

From this figure deduct:		
$ 94.00 for excess pages.		
103.72 payment for long article by Jean and Richard Fox		
$197.72		$ 197.72
		$6,528.81
Amount allowed in budget, including $75.00 for postage, printing, telephone, telegrams, etc.		6,375.00
Expenditure in excess of budget estimate		$ 153.81

Some of this difference is offset by the fact that the printer's bills, which were simply added to give total expenditures, include such items as making and patching cuts for advertisers, which are charged to the advertisers by the Association.

In order to try to keep within the budget the Editor corresponded many times with authors, with suggestions for condensation, elimination of tables, and rearrangement of illustrations. The editorial office occasionally went so far as to rough out condensations and make specific suggestions on the continuity where tables were omitted. Also, in the editorial office much time was given over to the mechanical details of making up plates from single illustrations, and cutting and trimming in order to come up with the least expensive type of reproduction that would still be acceptable. In most cases the authors were extremely cooperative and understanding, and readily acceded to the suggestions. When they had specific and valid reasons for not wishing to go along with the suggestions, their wishes were respected.

There were one or two instances where authors were on leave and could not be reached, in which case the editor had to go ahead as he thought best. For these instances, especially where the result was perhaps not in entire accord with the author's intentions, the editor expresses his regrets and apologizes. Most of the changes that were suggested and carried out were in the interests of economy.

The most expensive single feature of *Mosquito News* is the Bibliography or "Literature of Interest to Mosquito Control Workers and Malariologists" section. At the same time it is a feature which makes *Mosquito News* unique in its field and is of especial value to many workers. Dr. Lindquist has been exploring the possibility of a subsidy from some appropriate organization for this part of *Mosquito News.* In response to a letter from him pertinent figures were assembled in the editor's office. Since these are of interest to the members, a portion of the editor's letter to Dr. Lindquist on the subject is herewith quoted for the editor's report:

"The printing costs on the bibliography section of *Mosquito News,* based on the figures for the four issues of 1955, are as follows:

"30 pages at $28.76 per page, a total of $862.80.

"Each issue runs between 7 and 8 pages in the bibliography section. The charge of $28.76 per page is listed in our bills as *bibliography* and comes under the additional headings of 'foreign' and 'difficult' and in addition, is 8-point all of which adds to the cost."

It can easily be seen that any aid in financing this section of *Mosquito News* would contribute to an over-all improvement, since the size of each issue is definitely limited by the expense of printing.

The numbers of pages in the several departments of *Mosquito News* were distributed as follows in volumes 14 and 15:

	Number of Pages	
	Vol. 14 (1954)	Vol. 15 (1955)
Articles	146	163
Editorial	4	4
Association News	26	32
News and Notes	13	20
Reviews and Abstracts	3	7
Bibliography	31	30
Advertising	70	68
Miscellaneous	7	
Total	300	324

The printing company is no longer able to obtain the gray stock that has been used for covers. Of the stock that they have available at the same cost there are several attractive colors, and, beginning with Volume 16, it is proposed to adopt a new stock, possibly a somewhat livelier "granite effect" gray.

It is also proposed to add a new department to take care of short contributions on new techniques and ideas and brief accounts of how some innovation or new piece of equipment was put to use.

Such a department might be headed *Scientific Notes* or *Field and Laboratory Notes,* or *From the Shop, Field and Laboratory.* It would, of course, be in addition to the News and Notes Department, and would include material that is perhaps too short for a formal scientific paper, but not properly assignable to *News and Notes,* which is comprised more of news about people, meetings and organizations. Some of the items now included in *News and Notes* would more properly go into the new department. It is hoped that Mr. Morrill would continue to round up all such items and then leave it up to the editor to use his discretion in assigning some to the new department.

In conclusion, the Editor wishes to express his appreciation for the privilege of serving as Editor, and extends to all contributors, subscribers and AMCA members his sincere thanks for their cooperation and support.

Respectfully submitted,
D. L. COLLINS, *Editor*

ATTACHMENT #10

ANNUAL REPORT
GOOD NEIGHBOR CLUB
AMERICAN MOSQUITO CONTROL ASSOCIATION
Feb. 1, 1956

GENERAL

The annual campaign for the Good Neighbor Club was initiated in the fall of 1955. The objective was to obtain sponsors for the 25 existing "Good Neighbors" and to expand this number as much as possible. Letters of solicitation were written to approximately 100 Mosquito Abatement Districts, 75 commercial firms, 80 individuals, and 30 state and local health departments, mosquito control associations, etc. As of February 1, 1956, sponsors have been obtained for 72 Good Neighbors in 35 foreign countries. Thirty-three of these Good Neighobrs were adopted by 9 commercial firms, 28 by 25 individuals, 11 by 7 mosquito abatement districts, and none by health departments, associations, etc. These are summarized in table 1. With one exception, the 8 adoptions from foreign countries were by individuals stationed abroad.

The percent returns (no. favorable replies ÷ number requests × 100) and the

Good Neighbor ratios (no. Good Neighbors adopted ÷ no. requests × 100) for the four groups of candidate sponsors were as follows:

	Percent Return	Good Neighbor Ratios
Commercial firms	12	44
Individuals	31	25
Mosquito Abatement Districts	7	10
Departments and associations	0	0

Thus individuals provided the highest percent returns, but commercial firms provided the highest Good Neighbor ratios. The most important factor in obtaining a favorable reply was *contacting the right individual.* Eleven back numbers of *Mosquito News* were contributed to the Good Neighbor Club.

Numbers of Good Neighbors adopted by commercial firms, Mosquito Abatement District, and individuals during year ending February 1, 1956, were as follows:

COMMERCIAL FIRMS: Arthur S. LaPine Co., 2; American Cyanamid Co., 2; H. D. Hudson Mfg. Co., 11; Hickey Enterprises, 1; Neal A. McLean Co., 1; Monsanto Chemical Co., 1; Shell Chemical Co., 5; Silver Creek Precision Co., 5; Spraying Systems Co., 5. Total—33.

MOSQUITO ABATEMENT DISTRICTS: California—Consolidated M.A.D., 2; N. Salinas Valley M.A.D., 1. Illinois—Desplaines Valley M.A.D., 2; S. Cook County M.A.D., 1. New Jersey—Cape May County M.E.C., 1; Bergen County M.E.C., 1. Utah—Salt Lake County M.D., 3. Total—11.

INDIVIDUALS FROM FOLLOWING STATES AND COUNTRIES: California, 7; Georgia, 1; Maryland, 2; New Mexico, 1; Utah, 4; Washington, D. C., 3; Washington, 1; Virginia, 1; Canada, 1; Indo-China, 2; Philippines, 1; Saudi Arabia, 2; Switzerland, 1; Trinidad, B.W.I., 1. Total—28. Grand Total—72.

FINANCIAL

The following is a financial summary for the year:

Receipts		
Payments received from sponsors for 72 Good Neighbors		$360.00
Expenditures		
Stationery	$13.10	
Account book	1.40	
Postage	30.50	
Total expenditures	$45.00	$ 45.00
Net Profits		$315.00

RECOMMENDATIONS

It is believed that less confusion and more assurance of success would result if a campaign were initiated the latter half of each year to obtain sponsors for Good Neighbor memberships for the following year. In order to make this possible, it is recommended that the Association absorb the cost of the 25 original Good Neighbors which were on the books without sponsors through the major part of 1955. This would mean that the present 72 Good Neighbors would all be paid up through 1956, and a campaign could be initiated next fall for 1957 memberships.

Committee Members:
ROBERT L. VANNOTE
HELEN SOLLERS
ROLAND E. DORER
JOHN M. HENDERSON
GORDON E. SMITH
GEORGE A. THOMPSON
WM. J. BUCHANAN
MILTON H. BUEHLER
A. W. BUZICKY
C. DONALD GRANT
A. D. HESS, *Chairman*

ATTACHMENT #11

FINANCIAL STATEMENT ON MISCELLANEOUS PUBLICATIONS

December 31, 1955

CHECKING ACCOUNT

Balance as of January 1, 1955	$ 149.72
Total Deposits for the year 1955	+2,591.94
	$2,741.66
Total Expenditures for the year 1955	—1,683.85
Balance as of December 31, 1955	$1,057.81

STATEMENT

December 31, 1955

Bulletin	Number of Books Sold	Accounts Paid	Accounts Outstanding
1 & 2	1392	$2,739.00	$ 57.00
3	555	1,026.00	74.00

Bulletin #1, supply exhausted. This Bulletin has not been available for several months, and there have been very few requests for Bulletin #1.

Bulletin #2, remains in good supply. Calls for Bulletin #2 are falling off. Very few sales have been made in the past year.

Bulletin #3, remains in good supply, although orders for this Bulletin have slowed down materially in the last few months.

ATTACHMENT #12

REPORT OF THE HISTORICAL COMMITTEE

For the Committee appointed last year to prepare a history of the American Mosquito Control Association, I report with regret that no progress has been made. This is in part due to my long illness last spring and summer, and in part to my inability to obtain some of the most important material on the early events leading to the antecedent association of Eastern Mosquito Control Workers.

I suggest that the committee be continued in the hope that it will be able to produce results in the coming year.

Very truly yours,

HAROLD F. GRAY,
Chairman

Wanted: TECHNICAL DIRECTOR

for newly formed

NORTHWEST MOSQUITO ABATEMENT DISTRICT

(Chicago Area)

Send résumé and photograph to contact

H. K. BEEBE

ESSINGTON, MCKIBBIN, BEEBE & PRATT

231 SOUTH LaSALLE ST., CHICAGO 4, ILL.

NEWS AND NOTES

OUR REMARKS ON SEVERAL ANNUAL REPORTS PREVIOUSLY RECEIVED FROM MOSQUITO ABATEMENT DISTRICTS APPARENTLY INSPIRED OTHERS FOR TURLOCK AND SAN MATEO, CALIFORNIA, AND DESPLAINES, ILLINOIS, sent in theirs and they are all so good in entirely different ways that we would do them an injustice to try to abstract them here. You'll just have to send for them. The Desplaines report includes a large amount of population data for several species (Indexed!) and also describes some interesting comparative-suitability studies on various sorts of equipment in adulticiding. The report on the Turlock District gives a very complete breakdown of costs of operations for every type of control. The costs of vehicles, manpower and materials are analyzed and the report even tells how much of each insecticide was bought and *from whom!* (Boy, is that Ed Washburn ever brave!)

Don Grant, of San Mateo, has ye Assoc. Ed. sort of at his mercy, geographically, so we will give him a separate paragraph to butter him up. The San Mateo report, too, contains an excellent summary of costs and manhours, giving the proportions expended on source reduction, larviciding, ditch maintenance and new drainage, etc. Of especial interest, too, is the fact that Don has now added another pest to his District's control studies, one which is sometimes of major proportions and which is increasingly gaining attention in California, the biting genus of black gnats, *Leptoconops*. Don also recently sent us a preliminary but very instructive synopsis and key covering some of the culiciform diptera such as the Nematocera (Simuliids, Chironomids, Tipulids and Heleids). This is a symposium by members Brooks, Brydon, Grant, Keh, Kramer, Lauret and Mallars, and they expect to work it into a finished form within the next year. Its value is obvious and we wish, as the Irish say, that the wind may be always at their backs in this work.

CHESTER ROBINSON, OF ALAMEDA (CALIFORNIA) MOSQUITO ABATEMENT DISTRICT, reports that of thirty service calls in March, all but six were due to *Chironomids,* while the 35 service calls in February were all because of this nuisance. The District did considerable mist spraying to alleviate the inconvenience to residents caused by this pest. Elsewhere in California, where the floods of last winter had increased breeding areas and mosquito control measures had not also taken care of the midges, residual spraying of entries and fogging for adult control were being extensively practiced into April and May.

THE SKEETER, organ of the Virginia Mosquito Control Association, comes up with a nifty in the April issue. "At least, mosquitoes seem to be honest," Skeeters avers, "You might say that they settle their bill before each meal!!"

MO HIRST, in his Navy pep sheet, subtitled "More Hot Air from the Land of Sun," not to be outdone, comes back with, "Consider the mosquito: He rarely gets a slap on the back until he goes to work." (*She,* Mo.)

FRANCISCO DY WRITES, "We had quite a successful malaria conference in Phnom-Penh, Cambodia, last January. . . . WHO convened another inter-country malaria conference (The First Borneo Inter-territorial Malaria Conference) in Kuching, Sarawak, on 22–24 February 1956. This was attended by the Directors of Medical Services of North Borneo and Sarawak, the State Medical Officer of Brunei, and a representative of UNICEF. This was also a good conference. Among other things, the conference stressed the importance of achieving close co-ordination of national malaria programs, particularly among countries with common borders."

A press release on the Phon-Penh Conference, which Dr. Dy enclosed with his letter, states that the agreement was adopted by Cambodia, Laos, Thailand and Vietnam, and it closes with a statement by Dr. I. C. Fang, Director of the WHO Regional Office for the Western Pacific, that "mosquitoes recognize no territorial or political boundary." He also expressed his appreciation for the interest and material support given by the United States Operations Missions to public health programs.

HARRY STAGE, MAKING HANDSOME RESTITUTION FOR HIS MONTHS OF COMPARATIVE SILENCE, sends in a report on a malaria control study and observation tour, made during the period from 17 February to 20 March, 1956, which is packed with information on the Southeast Asian programs. The primary objective of the tour was to study the use of dieldrin as a residual spray (see previous News and Notes items by George Burton from Liberia and Nepal). Harry and his entourage visited the Institute of Medical Research in Kuala Lumpur, Malaya, the Malaria Control Headquarters of the English Army in Singapore, the Anti-Malaria Campaign Headquarters in Colombo, Ceylon, the anti-malaria bureaus of Rangoon, Insein, and Mandalay, in Burma, and several offices in Thailand. Control methods ranged from residual sprays, through the use of granules for the control of *Mansonia,* to fogging as an adulticide. This latter method, using hand-portable foggers, sometimes gave control for a very considerable period after a few initial applications and despite the fact that the fogs left no residuals in the area. Harry notes that again and again he heard emphasized the statement that *malaria control is not* MOSQUITO *control,* a point all can appreciate who have battled to control disease vectors and successfully done so only to have the area's inhabitants complain that "nothing has been

done about the damn mosquitoes." In areas having such tremendous populations of pest mosquitoes, largely breeding in carelessly-managed backyards and roadsides, the necessity of species control is especially marked.

MILTON BUEHLER SENDS IN THE PROCEEDINGS OF THE FIRST ANNUAL MEETING OF THE OREGON MOSQUITO AND VECTOR CONTROL ASSOCIATION, which was held the 17th and 18th of November of last year. It contains many good articles, but one in particular bears on this important subject just mentioned in the paragraph above. In "Species Identification as a Prerequisite to Control Operations," Professor Paul O. Richter points out many examples of situations where lack of knowledge of breeding habitats, gained through a thorough knowledge of species involvement, permitted widespread and completely fruitless activity in applying control to the wrong places. Lack of proper species identification can, he points out, result not only in controlling mosquitoes which are non-vectors of human or domesticated animal diseases but even of non-*biters* which may, by their numbers, be assuming the blame in the public mind for the sufferings inflicted by a far less numerous species.

HERB SCHOOF, OF THE COMMUNICABLE DISEASE CENTER AT SAVANNAH, GEORGIA, in amplification of his article which appeared in the March issue, writes that their program for the coming year will include further studies of the relative effectiveness of many types of applications, residual and transitory, for the control of adult mosquito infestations. The initial studies will be made under semi-field conditions, using caged flies and mosquitoes. Following this, operations will be conducted in and around premises.

T. E. MCNEEL, WHO HAS BEEN IN THE PHILIPPINES UNTIL NOW, is another of our illustrious members joining the malaria eradication program in Mexico. In line with the doctrine mentioned in Francisco Dy's report, that mosquitoes know no boundaries and control must be practiced jointly by countries having common borders, the eradication program is a joint effort and is projected to cover five years. Mac expects to be there for the first two of them, at least, and is adding his efforts to the previously-noted contributions of AMCA members Roy Fritz and Don Pletsch.

DR. HANNES LAVEN, A NEW GOOD-NEIGHBOR MEMBER WHO IS RESEARCHER IN GENETICS AT THE MAX-PLANCK-INSTITUT FÜR BIOLOGIE, writes a letter about his present studies on the *Culex pipiens* complex which is so interesting that we take the liberty of summarizing it for you. The starting point, writes Dr. Laven, was the detection of very strange crossing relations within the species complex, which he explained some years ago by hypothesizing cytoplasmic inheritance of the crossing type. But positive proof could only be made by formal genetic studies of the insects. This is now progressing and Dr. Laven has obtained several mutations by X-ray irradiation and has also picked up several spontaneous mutations.

"Besides the investigation of the crossing relations in *Culex pipiens,*" he continues, "I am planning to start with two other investigations: (1) the genetics of insecticide resistance in *Culex* and (2) the inheritance of autogeny vs. anautogeny in *Culex*. Both problems are in my opinion of some interest also for the control of mosquitoes. In the first-named problem the interest is obvious, because it is desirable to get information from an animal closely related to the many disease vectors . . . we have only information on the inheritance of insecticide resistance in the standard genetical animal *Drosophila*. The practical aspect of the second named problem is not so obvious. But according to my observations it is clear that the autogenous form of *Culex pipiens,* the so called *Culex molestus,* is only a mutant form of the anautogenous form. Two points must be remembered in this connection. The percentage of autogenous animals in every population of *Culex pipiens* varies with latitude; it is very high in the south and declines to the north. And this form is one of the voracious biters on human beings, at least here in Europe in cities and villages. There is also in this problem a practical aspect."

We hope that Dr. Laven's letter will inspire Members Roseboom and Hosoi (Doctors all) to do likewise and let us know what *they* have "cooking."

GEORGE BURTON MIGHT HAVE WRITTEN TO US ABOUT THE RECENT CORONATION IN KATHMANDU, NEPAL, which occupied so much of the attention of the world's press, but instead he chose to write to us about mosquito control in that remote and inaccessible kingdom. He does diverge to remark, though, that the weather is (or was up to then) ideal, not too cold, not too hot. Dr. Burton feels he has uncovered some hitherto unsuspected malarious areas as a result of the surveys he has been conducting by walking, by bullock carts and "where everything else fails, by elephant." Despite the fact that "the landscapes and panoramas are magnificent in this truly Shangri-La location," George insists that they manage to keep plugging. "We expect to begin our dieldrin spraying program after we get set up in Birgunj," he continues, leaving us wondering how that is pronounced, "And have a permanent base from which to work. At present we are using DDT in some areas, and still find it quite effective. In addition to the mosquitoes being knocked off, the flies are dying like flies."

FRED C. BISHOPP LEFT FOR EGYPT on January 25, 1956, to serve as advisor to the Egyptian Ministry of Agriculture under the United States Operations Mission in Cairo, a fact which should have been duly noted in our March selection of News and Notes, had we known of it. To those A.M.C.A. members who, like us, thought Dr.

Fred safely ensconced in Washington, D. C., and to whom the passing reference by Harry Stage to an expected meeting in Cairo may have been a little bit unsettling, our contritest apologies. Dr. Bishopp may be addressed at Cairo c/o U.S.O.M., via the U. S. Dept. of State, Washington 25, D. C., putting on the letter the correct postage to carry it via *regular mail to Cairo* . . . and may we hope that the mails will run *both* ways?

WELL, FRED STUTZ CAME THROUGH HANDSOMELY WITH HIS LIFE HISTORY, AS REQUESTED NOT TOO SUBTLY IN LAST MARCH'S ISSUE and we are happy to give you the lowdown on our new President. He was born (1898) raised and attended school in Chattanooga, Tennessee. In 1918, he started working for the U. S. Public Health Service as a field investigator doing malaria control work in Fort Oglethorpe, Georgia, nearby. Later that year he enlisted in the Student Army Training Corps and at the close of the war returned to the U. S. Public Health Service on a project known as "Studies and Demonstrations in Rural Sanitation." He continued in general public health work in Georgia, Alabama and Missouri with county health departments until 1926, when he was employed by the Coral Gables, Florida, Health Department. He continued here until 1935, when he was appointed Director of the then newly-formed Anti-Mosquito Districts of Broward and Dade Counties.

In 1939, Fred was sent by the U. S. Public Health Service to Brazil to study the methods used in the elimination of *Aedes aegypti*. Among the accomplishments of this period was the development of the use of paris green for the control of mosquitoes breeding in artificial containers. In 1947, he resigned from the Broward County District to organize and direct the activities of a Waste Department for Dade County which he now heads in addition to his other duties as Director of the Dade County Anti-Mosquito District. Fred is a past-President of the Florida Anti-Mosquito Association and has served as a member of the Vector Control Committee of the American Public Health Association. He says his hobby is "reading." Studies, we guess.

DR. LOUIS L. WILLIAMS, JR., HONORARY MEMBER OF THE A.M.C.A., AND AN HONOR TO US TO HAVE AS A MEMBER, a retired Medical Director of the U. S. Public Health Service, world-renowned malaria fighter, was a commissioned officer in the Public Health Service from 1915 to 1953. For 26 years a specialist in malaria control, Dr. Williams directed the Public Health Service, Office of Field Investigations of Malaria until 1940, when he became head of the Malaria Commission to the China-Burma Highway. During this more than a quarter-century period he was closely identified with, and guided the development of, many Divisions of Malaria Control in various State departments of health (he served as Divisional Director in Virginia after World War I). During the depression of the '30s he organized the malaria control programs of the U. S. Federal relief agencies and, at the start of World War II, organized and developed the office of Malaria Control in War Areas, and in time initiated their widely-known campaign for the eradication of malaria in the United States.

In 1943, Dr. Williams was detailed to the U. S. Army as Malariologist for the Mediterranean theatre of operations. He was PHS liaison officer to the Department of State from 1945 to 1948, participating in the development of the World Health Organization, after which he was assigned as Chief of the Division of International Health of the U. S. Public Health Service. He was a member of the U. S. delegation to the International Health Conference in 1946, in New York, at which the constitution of the WHO was drawn up, and in 1947, he was a delegate to the Pan American Sanitary Conference. That same year he was also a member of the organizing committee of the 4th International Congress on Tropical Medicine and Malaria.

After his retirement from the U. S. Public Health Service, Dr. Louis joined the staff of the Pan American Sanitary Bureau of the Regional Office for the Americas of the WHO, where he now is. He says his hobby is "International Health"!

NOW, G. EDWIN WASHBURN, WHOM WE HAVE HAD OCCASION TO MENTION FOR HIS HARD-WORKINGNESS AND INTREPIDITY, has had more to his life than these death-defying feats. He doesn't say so, which is almost as odd for a Californian as it would be for a Texan, but we believe that he was born in California, and not far from where he now resides. He worked as a proto-entomologist, along with some others of us, for Pete Simmons and W. D. Reed in Fresno, summers, and was graduated as a full-fledged entomologist by the University of California in 1932. After a considerable amount of graduate work, he then spent 9 years teaching Agriculture at the Reedley High School and Junior College. He was with the Public Health Service in the MCWA program during World War II and that was his downfall, for in 1946 he went out into the Turlock Mosquito Abatement District as its manager, and that he is today, as well as Secretary of the California Mosquito Control Association and Regional Director for the Pacific Southwest Region, A.M.C.A. Ed has three children, including 1 married son (incredible!) and 2 daughters in high school. He says music and farming are his hobbies but he spends most of his time on mosquito work, we've noticed.

DONALD R. JOHNSON, WHO IS NOW THE MAN IN THE DIVISION OF INTERNATIONAL HEALTH, OF THE PUBLIC HEALTH SERVICE, WHO SENDS ALL THESE PEOPLE OVERSEAS, was born in 1920 in Chicago, Illinois, and graduated from the University of that State in 1943, with his major in Entomology,

of course. From 1943 to 1946 he was in the Navy, and for 2 years of this time was Officer-in-Charge of Malariology Unit 72, in New Guinea and the Philippines. In 1946 he returned to school, at the University of Minnesota, receiving his M.S. in 1948, and until 1951 he was Assistant State Entomologist in that state. However, the virus of malaria control and the lure of the South Pacific eventually got him and he returned to Indonesia for the U.S.P.H.S. in assistance to the Indonesia Ministry of Health. He is presently in Washington, as we indicated above, luring people into these exotic and fascinating assignments. If anyone wants some information about the International Cooperation Programs in over 20 countries of the world, or is interested in a possible foreign assignment, write to Don. He is also Chairman of the A.M.C.A. membership committee and says his hobby is gardening. In Washington, however, gardening isn't really a hobby; it's an essential prophylaxis.

BEN KEH, ASSISTANT VECTOR CONTROL SPECIALIST OF THE CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, was born in Lodi, California in 1919, and received his B.S. in 1950 from the University of that State. In 1951, he obtained an M.S. degree, also from the University of California, and joined Dick Peters' Bureau of Vector Control, for which he had been working part-time since 1949, on a full-time basis. Ben says he has no hobbies except an epicurean collection of good eating places with an international flavor, but he has recently got himself a house, and now he knows what the hobby of all house-owners necessarily is. He says it's getting organized, though, so then it will cease to be a hobby. Ben's forte is all arthropods of medical importance, which leaves him wide open to be handed mites, ticks and such types which are hard enough to be universally shunned. His observations on mosquitoes have appeared in *Mosquito News* and aroused the interest of many members.

DR. ANTONIO EJERCITO Y LISA is Director of the Malaria Control Project (ICA) in the Philippines, who recently announced, with T. E. McNeel, a program for the eradication of malaria in the Philippines. Dr. Ejercito commenced his medical studies in the University of the Philippines, concluding them in the United States in 1923 and then returning to Manila where, in 1925 he joined the Division of Communicable Diseases of the then Bureau of Health. In 1927, he became assistant chief of the Malaria Control Section which he headed a few years later and guided in 1951 into the status of a full Division.

He has been an indefatigable delegate at conferences on malariology, his travels beginning in 1935 when he was sent as a delegate to the International Meetings on Malariology in Malaya and Java. In 1938, he attended the Third International Congress of Tropical Medicine and Malaria in Amsterdam; 1949 saw him in Rome at the Second World Health Organization Assembly, and in 1953 the Fifth International Congress on Tropical Medicine and Malaria in Istanbul. In 1953, also, he went to Rome to attend the Sixth International Congress on Microbiology and in 1954 he was the chairman of the Second Asian Malaria Conference for the Western Pacific and Southeast Asia Regions.

In 1953 and 1954, he travelled widely in the United States and many of our local control workers had an opportunity at that time to meet or to renew acquaintance with the genial doctor. Those who were stationed in the armed forces in the Philippines during and after the war have good reason to remember his plentiful help during a time when he was facing the disheartening ruins of his malaria control and was "stooping to build them up" with what proved to be far from "worn-out tools." Actually, the darkness was only the prelude to a bright new era. The success with which his efforts and those of other A.M.C.A. members like Archie Hess and Travis McNeel have been crowned is attested by the fact that it is now possible seriously to set forth a plan not alone for the control but for the eradication of malaria in the Philippines.

DR. LUANG AYURAKITKOSOL, Chief of the Division of Malaria and Filariasis Control, and the Deputy Director-General of the Department of Health, Ministry of Public Health of Thailand, one of our distinguished members residing out of the United States, was born and reared in Thailand. He has been actively engaged in the control of malaria in Thailand for over 20 years and in the control of filariasis for 4 years. Together with the late Dr. Bhayung Vejjasastr, Director-General of the Department of Health, Dr. Ayurakit pioneered the control efforts, establishing the first organized malaria survey unit in 1931, while Dr. Bhayung was studying at Johns Hopkins University.

Dr. Ayurakit received his formal training in the Medical College of Chulalongkorn University, Siriraja Hospital in Bangkok, and through Fellowships sponsored by the League of Nations, World Health Organization, and the Thailand Government for advanced studies in various institutions of Malaya, India, Italy, and Ceylon. He has appeared on the programs of International Conferences.

Prior to 1950 there were estimated to be 4,000,000 cases of malaria annually in Thailand of which 40,000 were fatal. Trained personnel were few, medical supplies scant, laboratory facilities and control measures inadequate . . . the problem seemed insurmountable. The inadequacies were more than off-set by Dr. Ayurakit's scientific ability, his courage to attack the seemingly impossible, his ability to inspire fellow workers, and his zealous desire to control the number-one-killer of his land. This long sought goal is being realized. His program has been expanded from a small survey unit to a control

organization protecting approximately 10,000,000 people. Rapid expansion has been made possible through a demonstration project sponsored by WHO and UNICEF and through the cooperation of the United States of America International Cooperation Administration during the past five years. The Thai and cooperating agencies were able to show that in areas where houses were sprayed for three consecutive years, the incidence of disease and vector became virtually zero. Plans for the next two years include protection for all who live in the malarious areas of the nation.

Dr. Ayurakit, on the eve of his retirement from the Department of Health, is touring parts of Europe, Asia, the United States, and the Pacific Islands, under the auspices of the ICA, observing the basic research, applied investigation, and public health activities on the federal, state, and local levels in preparation for expansion of his program for investigation and control of vector-borne diseases in Thailand.—E. B. THURMAN

WE CLOSE THIS INSTALLMENT OF WHO'S WHO WITH—ROLLIE DORER. Shux, it shouldn't be necessary to tell you anything about Rollie, who is a Founding Father and has been so long a quiet but effective Moving Spirit. Rowland E. Dorer, whose name is synonymous in most minds with Virginia, was actually born in East Orange, N. J., possibly in order to cement later inter-sectional mosquito control relations. With this auspicious start in 1907, Rollie progressed through the New Jersey schools and Rutgers University to eventual junction with his métier as an employee of the Union County Mosquito Control Commission. In 1933, he came to Virginia to be in charge of mosquito control, which has grown steadily and solidly, building up a strong backlog of loyal citizen support, and has now expanded to include control of all vectors affecting public health. In the Association, Rollie assumed official position as a member of the Board in 1949, continuing as Assistant Secretary and Treasurer, Treasurer, Vice-Chairman and President in the succeeding years through 1954. After "resting" this year as a mere Member of the Board, we trust Rollie will feel ready to start another cycle!

THE CENTRAL CO-OPERATIVE ANTI-MALARIA SOCIETY, LTD. OF CALCUTTA, INDIA, which is now nearing the end of its thirty-seventh year of charitably-supported anti-malaria activities, sends us its report for the year which ended with June, 1955. The road of such societies supported by donations has, of course, become far rockier since India attained her independence and while success seems reasonably assured the intervening pathway sets the challenge of unremitting labor. The Society is meeting this challenge with the solution of encouraging local, rural societies which bring the problem and demonstrate the solution to the individual villager, thus building a broad base of popular support. The Society also feels that it is, in this way, contributing to the solution of the over-population problem, since it is helping to make each individual capable of self-supporting productivity.

THE TOLEDO SEMINAR COMMITTEE made a report during the 1956 American Mosquito Control Association Meeting, in which the success of the Seminar was emphasized both from the financial standpoint as well as from the information gained. It was reported that 107 attended the gathering. Mr. Dick Girkins reported that receipts were $1,273.15 and a check for $338.33 was turned over to Lester Smith, treasurer of the A.M.C.A. The Seminar Committee will be turning over future receipts for the sale of the *Seminar Proceedings* from time to time in the future. The supply of these booklets is limited and there will not be any reprinting. Members are urged to make their purchase of the *Toledo Seminar Proceedings* now.—P. BRUCE BROCKWAY, JR.

MR. BROCKWAY ALSO CONTRIBUTES THE FOLLOWING: The Willys Motors was well represented at the Beaumont meeting of the American Mosquito Control Association by the fleet sales manager, Dick McMahan and his assistant, Paul Sutton. During the course of the meeting, these gentlemen met the official board as well as many members of the Association and explained the new cooperative approach that Willys is going to take toward those working in the field of mosquito control.

Through the Willys organization in Toledo, their zone and district managers and the 2,100 Willys dealers and distributors, the Fleet Sales Department has arranged for a standard discount of 15 percent. Purchase of vehicles and parts will be through the local dealer. Each Mosquito Control District will be provided with a complete Willys purchase list against which we may check the prices quoted by the local dealer. If the discount does not equal 15 percent, the Fleet Sales Department in Toledo should be contacted at once. The Fleet Sales Department will line out the dealer or else make arrangements for the sale to go through another local dealer who will play ball. Under this plan, the Association Members' money is spent locally and profits stay in the local area instead of going to the main Willys plant in Toledo. Also, this puts the factory in a position to demand that the dealer perform on parts and service. At the same time, a good local community relationship is built up between the Mosquito Control District and the local Willys dealer.

The whole plan is in the best interests of the American Mosquito Control Association. Mr. Dick McMahan and Mr. Paul Sutton are going to work hard to make it work and they will appreciate A.M.C.A. members' cooperation and patience until it works smoothly.

THE NORTHWEST MOSQUITO ABATEMENT DISTRICT is a newly-formed organization in the Chicago area, according to a notice received from Mr. F. P. Creadon. For information concerning the position of Technical Director, refer to their advertisement in this issue of *Mosquito News*.

TRAINING COURSE FOR MOSQUITO CONTROL SPECIALISTS. A training course for mosquito control specialists was held in Utah on February 21–25, 1956. The course was conducted by Dr. Harry D. Pratt, Chief, Insect & Rodent Control Training Section, C.D.C., U.S.P.H.S., Atlanta, Georgia. It was sponsored by the Logan Field Station of C.D.C., U.S.P.H.S., the Utah Mosquito Abatement Association and the University of Utah. The sessions were conducted at Farmington and Logan, Utah. Some forty individuals registered for the course and attended regularly; others were present for certain sessions. Assisting Dr. Pratt were members of the staff of the Logan Field Station, in particular Dr. Richard P. Dow, who was in charge of local arrangements. The managers and chief inspectors were present from six organized districts in the state; sanitarians and others interested in mosquito control from city, county, and state health agencies were in attendance, two of them from Boise, Idaho. In addition, members of the staff from Weber College and the University of Utah were in attendance accompanied by graduate students from the University who are majoring in entomology. The lectures, laboratory periods, and demonstrations were concise, well planned and interestingly presented. It is the unanimous opinion of those who attended the course that it was excellent. This concentrated, effective training course will undoubtedly help to improve the mosquito control program in Utah and the Rocky Mountain region.

Some of the Members Attending the Training Course for Mosquito Control Specialists Held in Utah, February 21–25, 1956

REVIEWS AND ABSTRACTS

Collecting, Preparing and Preserving Insects. By Bryan P. Beirne. Pub. 932, Science Service, Entomology Division, Canada Department of Agriculture, 133 pp., May, 1955. Price 50 cents. This publication was compiled by Dr. Beirne with the collaboration of other officers of the Systematic Entomology Unit and of other specialists. In a foreword G. P. Holland, Head, Systematic Entomology Unit, states that the publication was prepared for the use of amateur or professional entomologists.

Over a period of years numerous bulletins and pamphlets describing methods for the collection and preservation of insects have appeared. In addition similar material is presented in a number of textbooks. This latest publication was prepared with Canadian conditions in mind; the principles and techniques are, of course, of general application.

This reviewer finds that Dr. Beirne's contribution is excellent in all respects. It is certainly one of the most complete publications of its type. The material is divided into sections dealing with Equipment and Methods for Collecting, Equipment and Methods for Preserving and Mounting, Storage and Care of Collections, and Application of Methods. A section giving formulae and an index are included.

Mosquito workers will perhaps find the section on aquatic insects too brief while other groups are covered in much more detail. This unevenness is acknowledged in the foreword as being due to multiple authorship and emphasis on popular groups or groups of economic importance.

The inclusion of sections on arachnids and nematodes is justified quite apart from the stated reason that these groups are being studied by entomologists in Canada.

The only lacuna found by this reviewer, unless it was overlooked in a subsection, is the failure to mention the use of a plastic spray on certain pinned insects to reduce loss of delicate and brittle parts.

Specialists frequently are occasioned needless difficulty when improperly preserved material or material lacking essential host data is submitted for identification. The task of the specialist will be made easier if the amateur and professional entomologist alike pay closer attention to the correct methods of collecting, preparing and preserving insects.—A. S. West, Queen's University, Kingston, Ontario.

Egg Production in *Culex pipiens pallens* Coquillett. I. Seasonal Changes. By Teruhiko Hosoi. Jap. J. Med. Sci. Biol. 7(1):57–73. 28 refs. 1954. In English. 1. In the vicinity of Tokyo, *Culex pipiens pallens* Coq. is prevalent from May to November throughout, with maximum house-frequency and blood feeding about June and July. Female imagines over-winter usually in a state of complete hibernation and reappear from March to April.

2. There are extensive individual variations in biting activity and capacity for egg formation among wild females captured in any season of the year. In spite of the actual cessation of blood-sucking and oviposition during the winter, hibernating mosquitoes are capable of reproduction with greater or less ease under favorable conditions. This capacity decreases gradually from autumn to winter and rises rapidly in spring.

3. Wild larvae and pupae collected in the fall and bred in an unheated room give rise to females of reduced activity in a large proportion. When the breeding temperature was raised, the number of active females increased considerably.

4. An abrupt rise in temperature proved fatal to the majority of the hibernating females, although some individuals could be reactivated prematurely. Warming accompanied by illumination promoted termination of the diapause state in this mosquito.—Author's summary.

Egg Production in *Culex pipiens pallens* Coquillett. III. Growth and Degeneration of Ovarian Follicles. By Teruhiko Hosoi. Jap. J. Med. Sci. Biol. 7(2):111–127. 1954. 18 refs. In English. 1. Number of follicles developing or matured in the mosquito after one full feeding on human blood varies extensively even among individuals with equal wing length. There is found, however, a simple functional relationship between wing lengths and the means of these numbers.

2. When the mosquitoes are fed on human blood, degeneration occurs in a large number of follicles at the second stage of development. The ratio of these degenerating follicles is kept fairly constant among the mosquitoes with equal wing length, irrespective of the differences in the actual number of follicles produced or starting development in each individual.

3. Both the number of mature follicles and the rate of follicle development vary considerably, depending on the amount or kind of ingested blood. The results are not different from those obtained by previous workers with various species of mosquitoes.

4. Gonotrophic dissociation occurred not uncommonly among the mosquitoes fed on human blood in the laboratory. These mosquitoes, however, almost invariably matured eggs following the second meal, in a number larger than that which would be expected from the result of a single blood feeding.

5. Feeding on a 5 percent solution of casein promoted growth of the first-stage follicles, which developed to the second stage in some individuals; nevertheless only a small proportion of these follicles were able to develop beyond this stage.

Mosquitoes fed on hen's egg could develop a considerable number of follicles up to the final stage.

6. Blood corpuscles of chickens proved efficacious in promoting egg formation of the mosquitoes. Among various organs of chickens, the testis and the ovary were found to contain some growth factors, which could be utilized by the mosquitoes as supplements to casein in raising a large number of follicles to maturity.—Author's summary.

EGG PRODUCTION IN *Culex pipiens pallens* COQUILLETT. V. RELATION TO FATTENING AND BITING ACTIVITY. By Teruhiko Hosoi. Jap. J. Med. Sci. Biol. 7(3):231–240. 1954. 19 refs. In English. 1. The desire of female mosquitoes for blood feeding is not derived simply from a state of hunger. With respect to the biting activity of active females, it was virtually immaterial whether the mosquitoes had previously been starved or fed on a concentrated solution of sugar. In hibernating females, however, fasting seems prerequisite to resumption of blood feeding.

2. Illumination promotes various kinds of physiological processes in imagines. It increases flying and biting activity, and also promotes the first-stage development of follicles as well as both enlargement and diminution of the fat body.

3. Experiments involving abdominal ligaturing and transplantation of the ovary revealed that, in spite of the apparent correlation between the biting activity and the capacity for egg formation, the biting activity did not relate directly to the state of the ovaries. No evidence of maternal control of the follicle development was found, at least after the mosquito had taken a meal of blood. The ovarian follicles seemed to be able to commence development according to their own activity, as soon as their nutritional requirements were satisfied.—Author's summary.

EGG PRODUCTION IN *Culex pipiens pallens* COQUILLETT. II. INFLUENCE OF LIGHT AND TEMPERATURE ON ACTIVITY OF FEMALES. By Teruhiko Hosoi. Jap. J. Med. Sci. Biol. 7(1):75–81. 1954. 8 refs.

EGG PRODUCTION IN *Culex pipiens pallens* COQUILLETT. IV. INFLUENCE OF BREEDING CONDITIONS ON WING LENGTH, BODY WEIGHT AND FOLLICLE PRODUCTION. By Teruhiko Hosoi. Jap. J. Med. Sci. Biol. 7(2):129–134. 1954. 8 refs. These two papers, as well as Parts I, III, and V, will be of interest to workers in the field; and I shall be pleased to lend them to AMCA members. —HLTD.

HORMONAL CONTROL OF OVARY DEVELOPMENT IN MOSQUITOES. By A. N. Clements. J. exper. Biol. 33(1):211–223. March 1956. 28 refs. A study was made of ovary development in *Culex pipiens* form *molestus* Forskäl, an autogenous mosquito not needing food in the adult stage to develop its eggs, and in *C. pipiens pipiens* L. and other anautogenous mosquitoes which require blood for ovary development. Comparison of the reserves of fully grown larvae of the autogenous and anautogenous forms of *C. pipiens* showed that the autogenous form had a rather larger fat body, but that the anautogenous form contained sufficient protein reserves to develop a number of eggs. It was considered that autogeny did not depend solely upon the ability to amass extensive reserves but also upon some other physiological mechanism.

Decapitation and ligation at the base of the abdomen prevented ovary development in *C. pipiens* form *molestus* when performed within a few hours of emergence, but when performed 7 or more hours after emergence it often failed to prevent ovary development. It is suggested that a gonadotrophic hormone is secreted during this time.

Ligation of the abdomen within an hour of feeding on blood appeared to prevent ovary development in *Anopheles stephensi* Liston. Ovary development occurred in a small proportion of females ligated 2 or more hours after feeding, and this proportion increased with time. Ligation of the abdomen immediately after blood feeding failed to prevent ovary development in *Culex pipiens* form *berbericus* Roubaud, *Aedes aegypti* (L.) and *Anopheles labranchiae atroparvus* van Thiel, even in some cases where the ligature was tied within 2–3 minutes of the start of feeding. —Author's summary.

NOTA SÔBRE UMA POSSÍVEL MODIFICAÇÃO DE HÁBITOS DE ANOFELINOS DO SUBGÊNERO *Kerteszia* EM ZONA SUBMETIDA A DEDETIZAÇÕES DOMICILIÁRIAS. By Mario O. Ferreira and Carlos E. A. Azambuja. Rev. Bras. Malariol. e Doenças Trop. 7(3):367–369. 1955. The authors report the results of preliminary observations showing that in areas submitted to domiciliary DDT spraying the *Kerteszia* adults that were mainly captured on the internal surface of walls are found in marked predominance on external surfaces of the walls after some applications of DDT are carried out. They state that they are not yet sure whether the change is due to a repellent or irritative effect of the insecticide or a true modification of the habits of the *Kerteszia*. The results of further observations will be repeated in the future.—Authors' summary.

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Errata

In volume 16(1):43 of Mosquito News, section Adulticides and Larvicides under Rachou et al. change 1955 to read 1954; p. 47 of same number, section on Filariasis, under Rachou, Garcia et al. and Rachou, Ferreira et al. change 1955 to read 1954. In volume 15(3):188, section on Distribution, under Carpenter and LaCasse change 386 pp. to read 360 pp.

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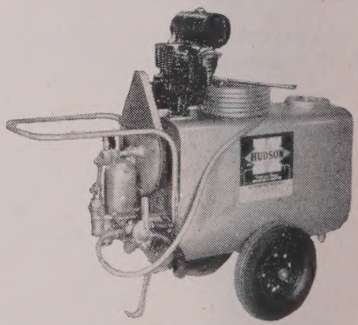

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